176

ENVIRONMENTAL INVESTIGATION AND HEALTH IMPACT ASSESSMENT

BRIDGETON SANITARY LANDFILL

Site: West Lake LDF
ID #: MOD079900932
Break: 3.4
Other:
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0714

Prepared for:

LAIDLAW

LAIDLAW WASTE SYSTEMS

Prepared by:

Golder Associates

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Superfund

JECT No. 923-6114 OCTOBER 1

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FINAL

ENVIRONMENTAL INVESTIGATION AND HEALTH IMPACT ASSESSMENT BRIDGETON SANITARY LANDFILL

Prepared for:

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October 21, 1993

Project No.: 923-6114

Laidlaw Waste Systems
3221 North Sevice Road
Burlington, Ontario, Canada L7N 3G2

Attention: Mr. Douglas Borro

RE: ENVIRONMENTAL INVESTIGATION AND HEALTH IMPACT ASSESSMENT

Gentlemen:

Golder Associates Inc. (Golder) is forwarding herewith a copy of the Final Report on the Environmental Investigation and Health Impact Assessment for the Bridgeton Sanitary Landfill Site. As you are aware, the completion of this challenging and interesting project is the result of efforts of professional staff from various Golder offices across the U.S.

We appreciate the opportunity to have provided our services to Laidlaw. Please do not hesitate to contact us if you have any questions, or should you need further assistance in the future.

Very truly yours,

GOLDER ASSOCIATES INC.

Femi Adeshina, Ph.D.
Senior Toxicologist/Project Manager

Geoffrey R. Forrest, C.P. Eng.
Associate

Enclosures

cc: Larry Giroux-Laidlaw
John Workman-Laidlaw

EXECUTIVE SUMMARY

An Environmental Investigation and Health Impact Assessment was conducted at the Laidlaw Sanitary Landfill Site (Site) located in Bridgeton, Missouri. The comprehensive environmental media investigation identified specific areas at the Site which appear to have been impacted by the low-level radioactive wastes deposited in Areas 1 and 2 of the adjacent West Lake Landfill. The latter is known to contain soil contaminated with low-level radioactive waste materials, including uranium-238 and -235, thorium-232 and their decay products. Elevated radon-222 and gamma radiation levels were noted at the landfill gas collection wells located in the northeast portion of the Site, and in the area of the Office building situated immediately west of Area 1.

The results of the potential health impact assessment at the Bridgeton Site indicate that measured concentrations of radon daughter products, to which on-site workers may be potentially exposed via inhalation, are almost 10 times below EPA regulatory limit 0.03 WL for indoor exposure. Furthermore, modeled radon gas flare emissions, to potential on-site workers and off-site receptors, indicate worst-case one-hour concentrations that are three orders of magnitude below the EPA's recommended 4 pCi/L **annual** average level for homes.

The potential ingestion of leachate- or condensate-contaminated water by on-site workers was found to be of no potential health concern because of maximum detected concentrations that were below EPA proposed maximum contaminant levels (MCLs) of 300 pCi/L (radon-222), and 20 pCi/L (radium-226) for drinking water. In addition, the detected leachate concentrations were also below the Metropolitan Sewer District recommended average monthly discharge limit of 600 pCi/L for radium-226.

The results of swipe tests in both office building, and on heavy equipment at the Site also indicate that potential incidental ingestion of transferrable contamination is not a viable exposure route.

The natural background gamma radiation levels at the Site were found to be generally consistent with natural external background levels in the United States. But at points where gamma levels exceeded background, the detected maximum gamma dose rate of 0.03 mrem/hr would result in an annual potential dose to Site workers orders of magnitude below the recommended exposure limit of 500 mrem/yr for infrequent public exposure.

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DEFINITION OF RADIOLOGICAL UNITS

Curie - The curie (Ci) is a unit rate of radioactive decay, and is the quantity of any radioactive nuclide which undergoes 3.7×10^{10} disintegrations per second. One picocurie (pCi) is equal to 10^{-12}Ci, which is approximately 2 disintegrations per minute (dpm).

rad - The unit of absorbed dose. One rad is equal to the absorption of 100 ergs per gram of material (e.g., human tissue).

rem - Rem is the unit of dose equivalent from ionizing radiation to the total body or any internal organ or organ system. It is equal to the absorbed dose in rads multiplied by a quality factor (to account for different radiation types). A millirem (mrem) is 10^{-3} of a rem.

Roentgen - A unit of exposure of X-ray or gamma radiation in air defined as 2.58×10^{-4} coulombs per kg. One roentgen (R) produces approximately 1 rad in tissue. One milliroentgen (mR) is 10^{-3} of a roentgen.

Working Level - The Working Level (WL) is any combination of short-lived radon daughters in one liter of air that will result in the ultimate emission of 1.3×10^{-5} MeV (2×10^{-5} Joule m^{-3}) of potential alpha energy. One WL equals 100 pCi/L equilibrium equivalent concentration.

Working Level Month - The Working Level Month (WLM) is an exposure rate of 1 WL for a working month of 170 hours. Under occupational exposure conditions, an employee exposed to 1 WL during a working year accumulates 12 WLM. In environmental situations, exposure is continuous, such that a person with continuous exposure to 1 WL accumulates about 50 WLM in one year. The following equation is used to relate WL and WLM:

$$\text{WLM} = \text{WL (Hours Exposed/170).}$$

1.0 INTRODUCTION

As per the terms of reference presented in Laidlaw Waste Systems (Laidlaw) Request for Proposal (RFP) of October 19, 1992, Golder Associates Inc. (Golder) performed an Environmental Investigation and Health Impact Assessment at the Laidlaw Sanitary Landfill Site (Site) located in Bridgeton, Missouri. This landfill is adjacent to a separate landfill site (West Lake Landfill) which is known to contain soil contaminated with low levels of radioactive waste materials, including uranium-238 and -235, thorium -232 and their decay products.

The major objectives of this health assessment include:

1. The development of an environmental sampling and analytical plan to identify and define areas contaminated by radioactive waste materials at the Site;

2. The evaluation of viable exposure pathways and the potential health impact of radioactive materials on on-site workers and off-site receptors; and

3. The identification of applicable regulatory exposure limits of radionuclides for occupational exposure conditions at the Site.

The health assessment presented in this report is divided into seven main sections. In Section 2.0, characteristics of the Site and previous environmental media investigations at the sanitary landfill are described. Section 3.0 contains a detailed description of the nature and extent of environmental contamination at the Site. Section 4.0 includes a discussion of the key toxicological properties of the detected radionuclides. In Section 5.0, a discussion of the potential exposure pathways, and a qualitative and quantitative assessment of potential radiological exposures are presented. Also, potential exposure doses to workers, under current exposure conditions at the Site, are determined and compared to applicable regulatory exposure limits in this section. Section 6.0 contains the conclusions on the results of this investigation, while specific recommendations concerning the potential occupational exposure conditions at the Site are presented in Section 7.0.

Presented in Appendix A is a summary of regulatory exposure levels for occupational and general public exposures to radioactive materials. Some of these regulatory levels may be applicable to working conditions at the Bridgeton Sanitary Landfill. The results of the sample analyses and recorded observations during the landfill environmental investigation activities are presented in Appendix B. The assumptions, input parameters for the exposure model, and results of modeled radon gas concentrations from flare emissions are presented in Appendix C.

2.0 SITE CHARACTERIZATION

The Site is located on St. Charles Rock Road west of the Taussig Road intersection in Bridgeton, Missouri. It is situated about one mile northwest of Route 270 and approximately 1½ miles east of the Missouri River, and is located in a combined rural-industrial area (Figure 1). The Site is approximately 200 acres in size. It includes an inactive quarry, stone and limestone processing and storage areas, and several active and inactive landfills. The nearest residential area (reportedly a trailer park) is located about 0.75 mile southeast of the Site. The Spanish Lake Village is a residential community of at least 90 homes reported to be located about 0.9 mile south of the landfill site (NRC, 1988).

Two known areas of the West Lake Landfill contain low-level radioactive waste materials (uranium-238 and -235, thorium-232 and their decay series). These areas are located on the same site as the Bridgeton Sanitary Landfill. West Lake Landfill, Inc. unknowingly received the radioactive material from the Cotter Corporation in 1973. In 1976, the Missouri Department of Natural Resources (MDNR) determined that about 8,700 tons of leached barium sulfate residues combined with approximately 40,000 tons of top soil had been placed at the West Lake Landfill.

The Area 1 wastes and contaminated soils reportedly comprise about 3 acres in the northeast corner of the West Lake Landfill (Figure 2). It is believed that approximately 20,000 cubic yards of radioactively contaminated materials are contained in this area (NRC, 1988).

Another possible contaminated zone (Area 2) has been identified based on an aerial radiological survey of the West Lake Landfill Site conducted in 1978 (NRC, 1988). This area is located in the northern part of the landfill and covers about 13 acres of the 200-acre property (Figure 2). About 130,000 cubic yards of contaminated soil are reported in this area.

A limestone ridge wall and a portion of a previously filled and capped quarry landfill separate the existing quarry pit from Area 1. The current landfill operation has an active, negative pressure landfill gas (LFG) collection system comprised of several LFG collector wells which feed a utility flare located east of Area 1. This area has since been quarried, filled with municipal solid waste (MSW), and capped.

A passive methane collection system, consisting of several individual large diameter concrete conduits, has also been installed in the current quarry pit which is presently being filled with MSW (the active area - Figure 2).

2.1 Previous Site Investigations

This section briefly summarizes the present understanding of applicable Site conditions based on information presented in the above RFP; personal interviews and telephone conversations with Laidlaw employees; and a review of the Phase I and Draft Phase II Environmental Investigations conducted by R.M. Wester & Associates.

In 1976, the U.S. Nuclear Regulatory Commission (NRC), Region III, investigated the disposal of radioactive wastes in the West Lake Landfill located adjacent to the Laidlaw Sanitary Landfill Site. This investigation revealed that about seven tons of U_3O_8, contained in 8,700 tons of leached barium sulfate residues, had been mixed with about 40,000 tons of soil at the Cotter Corporation Latty Avenue facility, and the entire volume disposed of at the West Lake Landfill. The results of previous radiological assessments indicate that the disposed materials contained uranium and/or thorium decay chain nuclides and potassium-40. The concentrations ranged from 1 to 19,000 picoCuries per gram (pCi/gm).

In 1978, a fly-over radiological survey that was performed for the NRC indicated radiation levels as high as 100 microroentgen per hour (μR/hr) in the area believed to contain the radioactive materials at the landfill. This area has been labelled as Area 1, but is neither owned nor operated by Laidlaw. The survey also revealed that a fill area at the landfill that was previously believed to be "clean" appeared to be contaminated with radioactive materials as well. Access to this area (designated as Area 2), which is neither owned nor operated by Laidlaw Waste Systems Inc., has subsequently been restricted to Laidlaw personnel.

The Phase I Environmental Investigation conducted by Wester Associates was designed to evaluate the potential impact of the radioactive waste materials on the currently active sanitary landfill operations, and to serve as the basis of a comprehensive Health and Safety Plan for Laidlaw employees. Because the waste materials deposited in the West Lake Landfill were residues of uranium ores from which uranium-235 had been extracted, members of the uranium-238 decay chain were expected to comprise the highest concentrations of radionuclides in the waste materials.

The Phase I investigation was focused on the associated hazards of potential exposure to the members of the uranium-238 decay chain. It was assumed in the study that, based on the maximum concentrations of deposited materials in the adjacent radioactive waste depositories, "it [was] highly unlikely that concentrations of surface contamination [were] sufficiently high enough to create an alpha and beta radiation hazard."

Ambient air monitoring for radon gas was conducted at the Site as part of the Phase I Environmental Investigation in order to assess the potential exposure to workers on the Laidlaw property. Both the LFG collection system and the leachate collection and discharge system were found to contain elevated (i.e., greater than background) levels of radioactive materials.

The Draft Phase II Environmental Investigation at the Site was designed to determine:

(i) the extent of radiological contamination in the leachate collection lagoon and discharge system; and

(ii) to evaluate the potential migration of radioactive materials from the adjacent radioactive waste depositories to the sanitary landfill (i.e., active MSW) via groundwater.

The report concluded with a statement that the presence of radioactive materials in certain areas of the landfill "exceed certain personnel protection action limits established by the various regulatory agencies," although the limits and agencies were not specified.

3.0 LANDFILL INVESTIGATION ACTIVITIES

3.1 Landfill Gas Collection System

Radon-222 gas samples were collected at the landfill on March 10 and 11, 1993 from selected sampling points (located by field-surveyed map coordinates as listed in Table 1 and indicated on Figure 3). These sampling points were located in the unsaturated soil zone (about 3 feet below grade). Sampling points were also located at selected LFG extraction wells.

The LFG samples were collected using sampling procedures and protocols described in Section 3.1.2 of this report. Following field analysis, the samples were analyzed by Core Laboratories (Casper, Wyoming) for Rn-222. The laboratory results were reported in picoCuries per liter (pCi/L). One pCi/L of radioactive materials (amount of radon-222 gas) in a sample of soil gas or LFG (collected from the unsaturated soil zone or gas collection well at the Site) is that quantity which undergoes 2.22 alpha-type disintegrations per minute (dpm).

The results of the LFG collection system evaluation are listed in Table 2. The analytical results included on this table show general background concentrations of Rn-222 at the Site to be less than 100 pCi/L. The distribution of Rn-222 within and adjacent to the LFG collection system is further discussed in Section 3.1.2.

3.1.1 Radon in the Unsaturated Soil Zone

Radon-222 is a heavy gas which is colorless, odorless and inert. It has a density of 9.72 grams per liter and is soluble in water. Radon-222, a natural isotope of the Uranium Series, is produced by the radioactive decay of radium-226 and has a brief half-life of 3.8 days. The radioactive decay of Rn-222 produces an alpha-type radiation.

The movement of Rn-222 in the unsaturated soil zone may occur through various mechanisms, including diffusion, convection, alpha particle emission recoil, pressure gradient flow, and water vapor transport. These transport mechanisms are described below.

- Diffusion: Radon-222 (as well as other LFG components[1]) may move from an area of higher concentration to one of lower concentration. This molecular diffusion through unsaturated soil is a net flux movement which is measured as the availability of alpha-decay particles per unit of time (e.g., 2.22 dpm) at a specific point and depth below grade at the Site.

  This radon flux is different from the radon content of the soil (Tillman, 1989). Radon flux is a variable which is significantly time- and location-dependent as well as physically dependent on the soil characteristics of the unsaturated zone (i.e., effective porosity, permeability, moisture content, etc.).

- Convection: Convection is the transport process whereby gas can move as a result of density and temperature differences. Radon-222, having a MW of 226.05, is about 14 times heavier than methane (MW of 16.04) and five times heavier than carbon dioxide (MW of 44.01). Typical soil gas (MW of about 29.2) is generally about 7.7 times lighter than Rn-222 and about 1.8 times heavier than methane.

  The temperature of the LFG (MW of about 29.4) is typically 90 degrees Fahrenheit (F) or 32.2 degrees Celsius (C). Significant temperature differentials in the landfill are not expected other than at the Site perimeter.

- Alpha Particle Emission Recoil: As the Radium-226 atom decays, it forms the isotope Rn-222. This alpha decay causes the radon-222 atom to be propelled in the opposite direction of the alpha particle (about 63 μm in the soil gas), provided soil moisture or other obstructions such as soil grains, buried refuse, etc. do not obstruct the atom's progress (Dillon, 1989).

[1]Methane, carbon dioxide, nitrogen, and oxygen comprise the main components of LFG, typically at concentrations of 44.0, 42.0, 10.5, and 3.0 percent volume, respectively (Golder Associates Report on Cache Creek Landfill, January, 1993).

- Pressure Gradient Flows: Soil gas pressure gradients may influence the direction and rate of radon-222 migration. The LFG interception zones developed along the line of ten gas collection wells located in the southwest corner of the Site may produce such pressure gradients towards the wells.

- Water Vapor Transport: LFG is typically saturated with water vapor produced during the anaerobic decomposition of MSW. This amount of water (about 2×10^{-4} gallon per each cubic foot of LFG) may solubilize a portion of the radon-222 gas and, subsequently, transport the gas with the LFG to the gas collection units. Colloidal-sized particles may also be similarly transported in the LFG.

The radon concentrations identified on Figure 3 illustrate the interpreted extent of Rn-222 across the 28-acre portion of the Site; that is, that portion of the entire 200-acre property which is located in the northeast corner. This 28-acre portion includes the 3-acre parcel which contains low-level radioactive soils comprising Area 1. The measured radon-222 concentrations range from less than 100 pCi/L (the maximum general background level) to about 1,770 pCi/L measured at sampling point P-5, near LFG extraction well W-8 (Figure 3). The analytical report and other pertinent data are summarized on Table 2 for samples collected on March 10 and 11, 1993.

3.1.2 Landfill Gas Sampling Methods

Gas samples were collected from the unsaturated soil zone using temporary probes passed through the cover material. A total of 26 gas samples was analyzed in the field for combustible gas content, oxygen content and hydrogen sulfide, as well as, relative soil gas pressure. Soil gas/LFG samples were also collected from temporary soil gas sampling probes and from wellhead sampling ports using 1-liter Tedlar bags. The samples were submitted to Core Laboratories for analysis within 24 hours of sampling.

The sampling protocols included documentation of the temporary gas probe reference number, date of sampling, name of the technician, weather and ground conditions, vegetative conditions, etc. The type of monitoring instrument and date of the most recent instrument calibration were also recorded.

A 3-foot barhole was then introduced into the ground using a weighted slide-hammer fitted to a 0.5-inch diameter solid-steel probe. Immediately upon removal of the probe, a 3-foot length of plastic tubing (connected to the MSA 62S and, subsequently, the GeoGroup IR Analyzer) was inserted into the barhole. To minimize air infiltration, the annulus between the plastic tube and the barhole was sealed at the ground surface. The maximum percent combustible gas concentration was measured in the barhole using the MSA 62S, and the oxygen and hydrogen sulfide concentrations were measured using the MSA 361. Carbon dioxide concentrations were, subsequently, measured in selected barholes using the GeoGroup IR Analyzer.

Following field measurement of soil gas pressures and primary LFG component concentrations, soil gas and LFG samples were collected using a 1-liter Tedlar bag placed in a vacuum box sampler. Sample collection was initiated by opening the vacuum box's bulk head port. The bulkhead port was closed when the Tedlar bag was approximately one-half full. The bag box vacuum release valve was opened, and then closed when the box pressure was in equilibrium with atmospheric pressure. Upon opening the vacuum box, and immediately closing the Tedlar bag inlet valve, the sample bag was disconnected from the vacuum box.

The soil gas/LFG samples were placed in appropriately labeled shipping containers, following collection, and later shipped to Core Laboratories. A sealed trip blank was also included in each sample shipment.

3.1.3 Methane Gas Collection System

The LFG collection system reportedly includes ten active gas extraction wells (W-1 through W-10) located at the northeast corner of the 200-acre property and about 14 active trench/well interceptors located in the easternmost portions of the Site (Mohror, 1993). The ten gas extraction wells reportedly deliver a minimum of 2,500 cubic feet of LFG per minute (cfm) to the main utility flare located as shown on Figure 2 (Durako, 1993). The easternmost LFG interceptor units deliver 1,500 cfm of LFG to each of the two utility flares located in the east/northeast portions of the Site.

Area 1 reportedly contains less than ten feet of contaminated soil overlying 50 feet to 65 feet of MSW which in turn, contacts the underlying alluvial sediments at an elevation of about 400 feet above mean sea level (amsl). However, the rest of the Site (the original quarry area) reportedly has a pre-landfill base elevation of about 250 feet amsl (RMC, 1981; Burns and McDonnell, 1986; Durako, 1993). Thus, given an average surface elevation of about 450 feet amsl, the general depth of MSW at the Site (beyond the immediate limits of Area 1) appears to be about 200 feet.

A comparison of Figure 4, "Interpreted LFG Pressure Contour Map" to, respectively, Figures 5 and 6: "Interpreted Methane Iso-Concentration Contour Map" and "Interpreted Oxygen Iso-Concentration Contour Map", illustrates the likely relationship between the LFG pressure gradients and the gas transport paths. Based on the greater rates of molecular diffusion of methane and oxygen compared to Rn-222, and the potential resistance of Rn-222 to convective flow towards the wells (based on radon-222 greater density), the comparable rate of migration of Rn-222 would be expected to be much less than the LFG.

The gamma radiation levels measured during the Site survey (see Section 3.5) are presented on Figure 7 as another indication of the probable relationship and effectiveness of the Bridgeton Site LFG collection system (gas wells W-1 through W-10). These interpreted contours illustrate the significantly higher gamma levels (compared to background (<2,000 counts per minute (cpm)) which were measured at the western and eastern ends of the line of gas collection wells W-1 through W-10. One of the highest gamma readings, in excess of 43,000 cpm, was measured at sampling point P-16, located about 100 feet to the northwest of the Site office. In general, it is notable that the gamma radiation data seem to indicate that the gas well field may be having a "localized" effect on LFG extraction at the Site.

3.2 Radon Gas Sampling - General Considerations

3.2.1 Sampling Method

Samples of the landfill gas introduced to the flares were collected in order to estimate the quantity of radon-222 released from the system. Nine 1.5 liter (L) gas samples were collected from separate locations and submitted for laboratory analysis of radon concentrations. The results of these laboratory analyses are presented in Appendix B. Three samples were collected at a point located between the blower and the main flare; three samples were collected at a location between the blower and the main station auxiliary flare. Three other samples were collected from the flare station located in the active fill (quarry), at a point between the blower and the flare. A field blank consisting of 1.5 liter ambient air was also collected adjacent to the main flare.

3.2.2 Results

Analytical results for the nine LFG samples, collected from the gas collection system adjacent to the flaring stacks, and the field blank are presented in Table 3. As indicated, the three samples collected at the main flare have an average concentration of 173 pCi/L, with a maximum concentration of 181 pCi/L.

The average concentration found in the auxiliary flare is 131 pCi/L, with a maximum concentration of 171 pCi/L (Table 3). The radon concentration for the third sample is 64.5 pCi/L. This concentration is significantly lower than those of the other samples. All three samples were, however, collected within 15 minutes of one another.

The average radon concentration found at the flare located in the active fill area is 69 pCi/L, and the maximum is 71.5 pCi/L (Table 3). These values are less than one-half the concentrations found at the main flare station. A detailed evaluation of these results is presented in Section 5.3.1.1 of this report.

3.3 Working Level Monitoring Investigation

3.3.1 Sampling Method

Employee work areas were monitored to determine radon daughter product levels using two active direct reading working level Thompson and Nielson TN-WL-02 monitors. The working level meter operates by sampling air from the environment at a constant rate, while radon daughter products are collected on a filter. Alpha particles are detected and counted by a customized integrated circuit. The TN-WL-02 meter counts a fixed percentage of the total alpha energy emitted and provides a time-integrated count rate. Working Level (WL) is calculated by using the manufacturer's specified formula: "alpha counts"/ [(sampling time - 0.5) x calibration factor]. The calibration factor is in counts per hour per milliworking level (cph/mWL) and is noted on the instrument at the time of manufacture.

3.3.2 Results

Working Levels were monitored during 10 distinct intervals and are summarized in Table 4. Representative sampling was performed within various employee work areas, including offices and vehicle cabs. Overnight monitoring in office buildings was also performed. Sampling intervals were approximately seven hours during day shift monitoring, and approximately 14 hours during overnight monitoring.

The WL meter was accidently shut-off during monitoring performed in the REX compactor cab on March 11, 1993. The estimated shut-off time is based on information from the compactor operator. However, the filters were replaced and the monitoring was re-initiated at 11:30 am. Due to the interruption, the sampling interval was limited to 5.27 hours. Monitoring performed in the cab of the D-8 dozer represents an undetermined length of time operating at the demolition landfill and at the active area of the sanitary landfill.

The highest level monitored, 0.0047 WL, occurred in one of the offices in the main building (Table 4). However, this level is approximately one-fourth of EPA's recommended limit of 0.02 WL in homes. The office was monitored two additional times. The average for the three observations is 0.0035 WL. It should be noted that the office building monitoring was performed under typical daily working conditions, rather than under EPA stipulated "closed house" conditions. It should be further emphasized that EPA "closed house" conditions require that windows and doors be closed and traffic through the building be minimized in order to allow radon daughter products to accumulate. A detailed evaluation of these results is presented in Section 5.3.1.1 of this report.

3.4 Worker Radiological Survey

3.4.1 Sampling Method

Employees were surveyed for radiological contamination at the commencement and termination of their working day by using a portable ESP-1 rate meter and HP-260 GM (pancake) probe. The survey was conducted by slowly moving the probe over the body surface and shoes (soles) of the employees while holding the instrument approximately one-half inch above the clothing and skin surfaces.

3.4.2 Results

Table 5 summarizes the employee radiological survey results. The results of this sampling event are reported as an average and a maximum activity level for each employee monitored. A total of 14 employees was monitored; however, two employees were not monitored prior to starting their shift, and one employee was not monitored after his shift.

Background levels of ionizing (gamma) radiation at sea level are typically 50 - 100 counts per minute (CPM) as measured by this instrument. Background counts in the rooms where surveys were conducted averaged approximately 40 CPM with a maximum of 90 CPM at the beginning of work shift (Table 5). Activity detected on employees at the end of their work shifts averaged 40 CPM with a maximum count rate of 102 CPM which is well within normal background variations. A detailed evaluation of these results is presented in Section 5.3.2.3 of this report.

3.5 Surface Radiation Survey

3.5.1 Sampling Method

A surface radiation survey was performed at locations where radon gas samples were collected and in areas where employees regularly work. The survey was performed using a portable rate meter and a high efficiency gamma scintillation probe. The probe was held between 6 and 18 inches above the ground surface, and approximately 1 m^2 of each sampling area was surveyed. An average count rate and a maximum count rate were recorded for each sampling location. A background count was also taken in an undeveloped area off the Earth City Expressway, approximately five miles from the landfill.

3.5.2 Results

Over 50 specific locations were surveyed in addition to a general survey performed around the edge of the leachate collection pond. Twenty-five of these locations are plotted on Figure 7, and the coordinates are presented in Table 1. Table 6 summarizes the results of the surface radiation survey. As indicated on this table, background readings for the gamma scintillation probe and rate meter used for the survey averaged 2,300 CPM. Average gamma activity at all the locations ranged from 700 CPM at the lagoon to 43,200 CPM at Point 16 (Table 6). A detailed evaluation of these results is presented in Section 5.3.3 of this report.

3.6 Determination of Transferable Contamination

3.6.1 Sampling Method

Transferable alpha contamination on heavy equipments and building surfaces at the landfill was evaluated to determine if this represented a potentially significant exposure pathway. A total of 18 samples was collected from areas that employees regularly contact. Locations included exterior surfaces of field vehicles, both the exterior and interior of cabs, and within Site buildings (Table 7). The samples were collected by wiping a 100 cm^2 area with a piece of Whatman 50 filter paper using moderate pressure. Only one side of the filter paper was used in order to prevent cross-contamination of samples. The samples were later placed in clean envelopes until alpha measurements could be performed. For most of the samples, this evaluation was conducted away from the areas where they were collected. The wipe samples were placed under the alpha scintillation probe, and alpha counts recorded over a 30-second period. Background alpha activity was recorded for the location at which each measurement was conducted.

3.6.2 Results

The degree of alpha contamination was determined by the number of alpha decays recorded during the 30 seconds that each sample was placed under the alpha scintillation probe. Presented in Table 7 are the sampled locations and the results of measured alpha radioactivity for each sample. A detailed evaluation of these results is presented in Section 5.3.2.3 of this report.

3.7 Personnel Breathing Zone Monitoring

3.7.1 Sampling Method

Airborne particles were collected at the Bridgeton Site from an employee's breathing zone during routine grounds maintenance activities (i.e., mowing) along the southwest edge of Area 1 of the adjoining West Lake Landfill. This area is known to contain low-level radioactive waste materials. Personnel air monitoring was performed using a portable personal air sampling pump connected to a filter cassette by plastic tubing and attached to the employee's waist band, while the filter cassette was attached to the employee's shirt collar. The sampling train, pump, tubing and cassette were calibrated using a soap bubble calibration tube and rotometer, set at a flow rate of 2 L/min. Instrument calibration consisted of measuring the time required for a soap bubble to travel 100 mL at various flow rates and recording the time and rotometer setting. Flow rates were recorded five times and an average value was calculated. Following completion of the monitoring, the cassette was disconnected from the tubing, and both ends were sealed with plastic plugs.

3.7.2 Results

Personnel breathing zone was monitored for 30 minutes and the results of the radiological analysis of the filter cassette (using EPA Methodology 900.0) are summarized in Table 8A. As indicated on this table, gross alpha activity was measured at 0.2 +/- 0.5 pCi/L, while gross beta activity was detected at 0.5 +/- 0.9 pCi/L in the analyzed sample. A detailed evaluation of these results is presented in Section 5.3.3 of this report.

3.8 Personnel Radiation Exposure Dosimetry

3.8.1 Sampling Method

A thermoluminescent dosimeter (for recording external radiation exposure) was used to monitor potential employee exposure during grounds maintenance activities (i.e., mowing) at the Bridgeton Site. The passive gamma dosimeter provides an accurate and sensitive method for measuring external radiation dose, with an exposure range of 10^{-2} rem to 10^{5} rem. One dosimeter was worn during mowing along the southwest edge of the radiologically contaminated Area 1 (on the adjoining West Lake Landfill). A second dosimeter was also used as a control device during this investigation. When not in use, the experimental gamma dosimeter was stored at the same location as the control dosimeter. The dosimeter was worn for a total of approximately seven hours, and the initial and final time for each event was recorded.

3.8.2 Results

The results of the radiation dosimetry for the measurement of the external radiation exposure are presented in Table 8B. As indicated, the gamma radiation dose was reported below the analytical detection limit of <10 mrem for both the experimental and control dosimeters. A detailed evaluation of these results is presented in Section 5.3.3 of this report.

3.9 Leachate Collection System

3.9.1 Sampling Method

Four water samples were collected from the lagoon discharge overflow and were assumed to be representative of leachate discharged to the sanitary sewer system. Two 1-liter samples and duplicates were collected, plus duplicates collected in Volatile Organic Analysis (VOA) vials. An initial grab sample was collected in a 2.5 gallon open container and apportioned into 1-liter polyethylene sample bottles, and the glass VOA vials. Samples in the VOA vials were then placed in a cooler containing blue ice. The 2.5 gallon container was rinsed three times with distilled water and discarded. Distilled water was placed in the container and used to fill one 1-liter sample bottle and two VOA glass vials. These samples represented equipment blanks. Leachate samples collected in the 1-liter polyethylene bottles were analyzed for gross alpha, gross beta, and radium-226. The VOA vials were analyzed for radon-222.

3.9.2 Results

The results of the leachate sampling analyses are summarized in Table 9 and presented in Appendix B. Radon-222 concentrations were reported to be 240, 266 and 284 pCi/L in the analyzed leachate samples, and below the detection limit of 206 pCi/L in the equipment blank.

Radium-226 concentrations were measured at 1.4 pCi/L in the leachate samples and below detection limit (0.6 pCi/L) for the equipment blank (Table 9). Gross beta activity was measured at 84.7 pCi/L in the leachate sample and 4.8 pCi/L in the equipment blank. Gross alpha activity was reported below the analytical detection limits of 19.3 and 2.0 pCi/L, respectively, for both the leachate sample and the equipment blank. A detailed evaluation of these results is presented in Section 5.3.2.1 of this report.

3.10 Landfill Gas Condensate

3.10.1 Sampling Method

Landfill gas condensate was collected (in accordance with SW-846 sampling methodology) from the condensate tank located at the main landfill gas extraction system. A 1-inch drain plug on the condensate tank was removed and a plastic tube was used to siphon condensate from the tank. A grab sample was collected into a 2.5 gallon open container and apportioned into a 1-L plastic container, and four 40-ml glass VOA vials. A second 1-L plastic container and another set of 40-ml VOA vials were filled as duplicate samples. The open top container was rinsed three times with distilled water and discarded. Distilled water was again placed in the container and used to fill one 1-L plastic bottle and four 40-ml VOA vials for equipment blanks. Condensate samples collected in the plastic bottles were analyzed for radium-226, gross alpha and gross beta radioactivities.

A second condensate sample was collected from the landfill gas extraction system for radon-222 analysis. This sample was collected from a low point in the extraction system located adjacent to Condensate Drain No. 3. A grab sample was collected in a 2.5-gallon bucket and apportioned into one sample and a duplicate each consisting of two 40-ml VOA vials. The 2.5-gallon bucket was rinsed three times using distilled water which was then placed in the bucket, and used to fill two additional VOA vials for the equipment blank.

3.10.2 Results

The results of the condensate sampling analysis are summarized in Table 10. Radon-222 concentrations were reported to be 244 pCi/L in the second condensate sample, 309 pCi/L in the duplicate, and 295 pCi/L in the equipment blank. Radium-226 concentration in the first condensate sample was reported at 0.4 pCi/L, but was not detected in the duplicate sample or in the equipment blank. Gross alpha activity was measured at 3.6 pCi/L in the sample, but was not detected in the duplicate and the equipment blank samples. Gross beta activity was detected at 10.1 pCi/L in the sample, 5.4 pCi/L in the duplicate, but not detected in the equipment blank. A detailed evaluation of these results is presented in Section 5.3.2.2 of this report.

4.0 TOXIC EFFECTS OF RADIATION

The information presented in this section is a general discussion of the health effects of exposure to radiation and radioactive materials. It is not an interpretation of the health impacts that may be associated with potential exposure to the low-dose radiation present at the Bridgeton Landfill.

The radioactive materials that have been detected at the sanitary landfill include radium-226 and radon-222. Both are naturally occurring elements, and have half-lives of approximately 1,600 years and 3.8 days, respectively. These radionuclides are members of the uranium decay chain and they emit alpha particles and gamma rays. Human exposure to members of the uranium series depends on the physical and chemical behavior of the particular element, and the exposure is via three main routes: inhalation, ingestion, and external radiation. The short-lived radon daughters represent an inhalation hazard and deliver significant dose to the bronchial epithelium of the lungs. If internalized, the radon daughters, uranium, and radium will tend to concentrate in the bone with concomitant dose delivered to bone surfaces. The external gamma emitters, and to some extent the Po-210 in the body, tend to irradiate the whole body.

It is important to note that, in the case of exposure to radon and radon daughters, the ingestion route delivers only a small dose in comparison to inhalation or external whole-body radiation. Further, in most circumstances, the external whole-body dose is significantly less than the dose to lung resulting from inhalation. Thus, it is inappropriate to consider these varied doses to different body organs as being directly additive (NRC, 1988).

4.1 Ionizing Radiation

When ionizing radiation interacts with matter, it strips atoms of their electrons. In living tissue, this can result in direct cell damage, or indirect cell damage caused by toxic by-products. Examples of ionizing radiation are gamma and X-rays, and alpha and beta particles. The following constitute four major sources of human exposure to ionizing radiation:

1. Natural sources of both internal and external irradiation;
2. Medical and therapeutic sources for cancer treatment;
3. Nuclear reactions, such as nuclear power reactors and weapons; and
4. Industrial X-ray machines, and consumer and industrial products.

Acute Exposure

In general, the acute whole-body radiation exposure to moderate and high doses (>50 rads) of irradiation is likely to occur only under accident situations at nuclear plants, nuclear warfare, or possibly during manned space flights. Such high doses are usually delivered at relatively high dose rates (several rads per hour), and the acute effects, which include a combination of gastrointestinal and neuromuscular symptoms, are threshold phenomena and dose-rate dependent (Klaassen et al., 1986). It is important to note that the manifestation of early effects occur only at fairly high doses (>50 rads). That is, at doses much higher than those that could be associated with potential exposure at the Bridgeton Landfill Site. The incidence and severity of the effects also increase non-linearly with increasing exposure dose (Klaassen et al., 1986).

Again, it should be emphasized that any adverse health effects that may be associated with moderate to high doses (>50 rads) of ionizing radiation will not be manifested at the very low exposure doses that are present at the Site.

Chronic Exposure

Evidence of radiation-induced lung cancer, following chronic exposure, is based on experience with uranium miners exposed to radon gas and radon daughters at very high levels. It should be, however, noted that the highest measured concentration at the Bridgeton Site (i.e., 0.0047 WL, or, 0.056 WLM) is orders of magnitude lower than the levels found in the uranium mines (i.e., 4 to 10,000 WLM) (Whittemore and McMillan, 1983).

Epidemiologic studies have also demonstrated a dose-effect correlation between very low doses of X-ray irradiation received in utero and cancer incidence in children. It is also important to emphasize that there is still a great deal of controversy on the magnitude of the potential cancer risk that may be associated with exposure to low and very low doses of ionizing radiation.

4.2 Specific Radionuclides

The toxicity of internally deposited radionuclides is very specific to each radionuclide. Therefore, a brief discussion of the toxicological characteristics of the radionuclides of interest at the sanitary landfill site will be presented in this section.

Radium

Radium is a metabolic analog of calcium and it is, therefore, deposited in the skeleton where it irradiates bone and adjacent tissues with alpha radiation at a dose rate that decreases slowly with time (Klaassen et al., 1986). Studies of groups of industrial chemists and women factory workers who were occupationally exposed to luminous paints containing radium, have demonstrated an increase in the incidence of bone cancer in heavily exposed persons.

Epidemiologic studies have also clearly established that radium induces carcinomas (cancer) of the mastoid and paranasal air sinuses. However, the lower the burden of radium in the body, the later and less frequent is the occurrence of malignant tumor with subsequent fatality (Klaassen, et al., 1986).

Radon and Radon Daughters

Radon gas, which is produced by the decay of radium, is inert and migrates easily through air. If inhaled, some of it will be absorbed into the blood from the lungs and be, subsequently, transported throughout the body while the rest is exhaled (NRC, 1988). Radon daughter products are particles which form directly in air from radon gas. Upon decay, the radon daughters emit alpha particles which are potent ionizers. But because of their relatively large mass and double positive charge, alpha particles do not penetrate deeply in tissues (Paustenbach, 1989).

Radon daughters (Po-218, Pb-214, Bi-214, Po-214) tend to attach to respirable dust particles. Inhaled radon daughters lodge in the deep lung and emit their alpha particles directly into the bronchial epithelium. The principal health effect of ionizing radiation associated with alpha-emitting radon and radon daughters is lung cancer. Smokers who are exposed to radon and its daughters are at a much greater risk of developing respiratory lung cancer due to the synergistic effects (i.e., multiplicative interaction) of the dual exposure (NRC, 1988).

5.0 HEALTH IMPACT ASSESSMENT

5.1 Introduction

Human health impacts resulting from environmental contamination are a function of both exposure and toxicity. Although a contaminant may be inherently very toxic; however, it will not pose a hazard to human health unless an exposure pathway (e.g., dust inhalation) is viable, resulting in a subsequent "dose". Conversely, many environmental contaminants to which the general public is continuously exposed are of little concern because they are not very toxic.

This assessment evaluates potential health impacts to workers associated with current Site conditions. It is assumed that Areas 1 and 2 will remain inactive in terms of landfill operations, and also, that the soils in these areas will not be disturbed. The potential health impact of airborne radon emissions on landfill workers on-site, and the potential impact on residential populations off-site were considered in this assessment.

The potential exposure pathways through which workers at the Site may become exposed to radiation are evaluated in Section 5.2. An assessment of the potential radiation doses (i.e., health impacts) that may be associated with potential exposures is presented in Section 5.3

5.2 Exposure Pathway Analysis

There are generally three routes through which people may be exposed to ionizing radiation: inhalation of radioactive gases or particles, ingestion of radioactive particles, and external exposure to gamma radiation. Soil contaminants may also deposit on the skin; however, with the exception of radioactive materials entering an open cut or wound, the dermal exposure route is relatively unimportant at the Site. Therefore, this route is not considered in this assessment.

The radioactive properties of a substance cannot be changed by any chemical or physical process. Consequently, any radon present in the landfill gas stream will not be destroyed, nor will its radioactive properties be altered in any way by the flare combustion process. Instead, radon gas will be emitted intact to the atmosphere. Although radon is approximately eight times heavier than air, given the extremely low concentrations of radon (relative to the concentration of other gas molecules), Brownian motion will keep the radon "suspended" in the gas stream from preferentially "settling-out." The dispersion characteristics of the radon are assumed to be identical to the flared landfill gas.

5.2.1 Air Exposure Pathway

5.2.1.1 Inhalation of Radon in Flares

Radon gas concentrations measured in the landfill flare gas at the Bridgeton Sanitary Landfill ranged from 64.5 pCi/L (picoCuries per liter) to 181.0 pCi/L, while a single ambient air sample taken on the active landfill in the immediate vicinity of the gas collection system contained 5.9 pCi of radon gas per liter of air (Table 3). An airborne radon concentration of 4 pCi/L is typically associated with the EPA's recommended action level of 0.02 Working Levels (WL) averaged over a one-year period for considering remediation of radon in homes (40 CFR 192). Hence, the radon concentrations observed at the Bridgeton Site may be raised as a potential issue.

Gas Emission Modeling

A simple screening procedure using the "flare option" of the EPA's UNAMAP Series 6, "SCREEN" Exposure Model (EPA, 1988) was performed to evaluate the potential impact of radon gas emissions associated with the landfill gas collection system on ambient air quality. As the name implies, the SCREEN exposure model is a very simple "first cut" screening tool. What the model gains in simplicity, however, is sacrificed in accuracy because of conservatism. The exposure model calculates the one-hour average concentration at user-specified distances on a line directly downwind from the source, for each of the windspeed/stability class combinations shown in Table 11. The model estimates the maximum one-hour concentration found for the worst-case meteorological conditions (wind speed/stability class combinations) at each specified downwind distance, and iterates to find the concentration and downwind distance of the "maximum" one-hour maximum concentration. Consequently, as far as properly applied Gaussian dispersion modeling is concerned, the results of the SCREEN exposure model are truly "worst-case" exposure estimates.

The SCREEN exposure model requires emission rates to be entered in units of grams per second (g/s), and reports calculated concentrations in micrograms per cubic meter ($\mu g/m^3$). Radon emission rates for the present application were calculated based on measured radon concentrations in the gas stream in pCi/L, and maximum design capacities of the flares/blowers in units of cubic feet per minute (cfm). Radon gas emission rates were input in the model in units of milliCuries per second which results in calculated ambient air concentrations being reported in nanoCuries per cubic meter, which is exactly equivalent to picoCuries per liter.

The base of the main flare is at an elevation of approximately 472 feet. The auxiliary flare is located approximately 50 feet from the main flare at an elevation of 460 feet. The 8-inch utility flare is assumed to be located in the immediate vicinity of the GC-2 well at an elevation of 330 feet with a 150-foot (i.e., 46-meter) cliff located approximately 500 feet (i.e., 150 meters) to the southeast. The SCREEN exposure model has options for "simple" (flat) terrain, "elevated" (below stack height) terrain, and "complex" (above stack height) terrain.

The model was used once for the main flare while assuming simple terrain, and was also used twice using both the simple and elevated terrain options for the auxiliary flare. In the latter case, it was assumed that the terrain is elevated four meters above the base of the auxiliary flare, or the approximate elevation of the main flare. Furthermore, the model was also applied twice for the 8-inch utility flare, using both the simple and complex terrain options. A 46-meter feature, located 150 meters from the base of the flare, was assumed in the latter case.

The modeled maximum hourly radon gas concentrations for specific maximum downwind distances are presented in Table 12. The assumptions, input parameters for the exposure model, and computer printout of modeled radon gas concentrations, due to landfill gas flare emissions, are included in Appendix C. An evaluation of the potential health impacts of exposure to predicted gas concentrations is presented in Section 5.3.1.2

5.2.1.2 Inhalation of Radon in Soils

The air exposure pathway is a viable means of receptor exposure if radioactive materials are present on the ground surface, and are in a form such that these materials can be resuspended in the air as dust. If radioactive materials are contained (i.e., covered with uncontaminated soil or an equivalent material), and if the cover is stable and not disturbed, then such contaminants will not be available for erosion and wind transport. Thus, the fugitive dust inhalation pathway will not be viable. Currently, there are only a few small areas in which contaminated soils at the adjacent West Lake Landfill protrude to the surface (RMC, 1982; Lambert, 1992 and 1993). Consequently, swipe samples of buildings and heavy equipment, and "frisking" of landfill employees for potential radiological contamination indicate that contaminated fugitive dust is not of concern at the Bridgeton Sanitary Landfill.

Thus, inhalation of fugitive dust by on-site workers is not considered as a potential exposure pathway in this assessment.

The inhalation pathway may be significant if radium-224 or -226 (the precursors of radon-220 and -222) are present in the soil within the first few feet. Under such circumstances, radon may migrate to the surface and be dispersed into the air. Radon emanation from soil is partially a function of the depth of the parent material (radium), and atmospheric conditions (barometric pressure). Buried gas collection lines, operating under negative pressure, actively draw radon gas out of the soils. Under normal conditions, this radon may otherwise have been too deep to reach the ground surface before decaying. In addition, the radon which could have conceivably escaped from the soils over a large area at the Site is currently collected and discharged as point sources in the gas flares.

Radon is known to be present, and is considered to be a potentially significant contaminant at the Site; hence, the potential inhalation of radon (and its decay products) in soils by on-site workers has been considered in this assessment.

5.2.2 Soil Exposure Pathway

Ingestion Scenario

The soil ingestion pathway is viable if radioactively contaminated soils in the landfill are uncovered such that people may come in contact with them. Such ingestion will be incidental -- resulting from close physical contact with soils. If the contaminated soils in Areas 1 and 2 of the West Lake Landfill are not disturbed, and if they are covered with a sufficient amount of clean material, the ingestion pathway will not be viable. As with the fugitive dust inhalation pathway, the soil ingestion pathway is not considered to be complete at this Site because the areas in which contaminated soils are exposed are small and access by Laidlaw personnel is restricted (RMC, 1982; Lambert 1992 and 1993).

Consequently, the potential ingestion of radioactively contaminated soils by on-site workers is not of concern.

5.2.3 Leachate/Condensate Exposure Pathway

Ingestion Scenario

Leachate is collected in a lagoon at the Site where it is aerated before being discharged into the Metropolitan Sewer District System. Gas condensate at the Site is collected in a tank located at the main landfill gas extraction system, and eventually emptied into the leachate lagoon. It should be noted that potentially contaminated leachate and/or condensate are not ingested by Site employees. However, as worst- case scenarios, leachate and condensate are considered in this assessment with respect to potential ingestion.

5.2.4 External Exposure Pathway

An external exposure pathway does not require physical contact with radioactive materials. Rather, certain types of radioactive materials emit photons (gamma and X-rays) which can actually penetrate soil, clothing, and skin. The significance of this pathway is dependent on the type and quantity of radioactive material present, and the thickness of the uncontaminated soil cover. Most of the radionuclides present in the landfill do not emit photons, or emit photons that are of such low energy that they are not highly penetrating. One meter (i.e., 3.3 ft) or less of clean soil cover is sufficient to shield against these photons. Some of the radionuclides which are present (e.g., bismuth-214) emit relatively high energy photons. But these emissions, however, would be completely shielded by 3 meters (i.e., 10 ft) of soil. Because much of the contaminated soil at the adjoining West Lake Landfill is currently covered, the external exposure pathway is only applicable to a few small areas. This pathway is, however, included in this exposure assessment.

5.3 Evaluation of Radiation Doses

The evaluation of potential radiation doses to workers at the Site is based on the conclusions from previous environmental investigations, analytical results of the current investigation as outlined in Section 3, and the exposure pathway analysis conducted in Section 5.2 of this report. The evaluation of potential radiation doses to off-site receptors is based on modeled airborne radon concentrations in flare gas.

5.3.1 Inhalation Dose Estimates

5.3.1.1 Measured Radon Concentrations

By convention, radon exposure is measured in terms of working levels (WL), while cumulative exposures over time are measured in working level months (WLM). One WL is defined as that concentration of radon daughters in 1 liter of air which has a potential alpha particle energy release of 1.3×10^5 MeV (million electron volts). This is approximately the amount of alpha energy emitted by the short half-life progeny in equilibrium with 100 pCi of radon. The WLM unit of exposure is defined as an exposure to an average of one WL for a working month of 170 hours (NRC, 1988).

Working level (WL) meter data indicate that the highest concentration of radon daughters to which employees may be exposed is 0.0047 WL (detected in the main office building). This concentration is consistent with other measurements taken in the same building (0.0037 WL and 0.0023 WL).

Working level measurements were also taken in 1980 by Radiation Management Corporation (RMC, 1982). The highest levels were reportedly detected both near and inside the Shuman Building (within Area 2), with a reported maximum of 0.031 WL.

The EPA standard for indoor radon decay-product concentrations due to uranium and thorium mill tailings (40 CFR 192) is a limit of 0.03 WL, including background, in any occupied or habitable building. The highest detected WL measurement to date (within Area 2 in 1980) is only slightly higher than this limit. However, recent measurements at the Bridgeton Landfill Site (Table 4) are nearly 10 times lower than the EPA limit.

Therefore, based on the criterion of 0.03 WL for indoor radon, the above analytical data indicate that the inhalation pathway at the Site does not pose a potential threat to the health of workers.

Comparison of radon concentrations in flare gas to radon concentration limits for homes or buildings is not appropriate because flare gases loft and disperse significantly before descending to a location where persons may be exposed to flare emissions. However, because Site personnel may be exposed to flare gases when servicing gas collection and flare equipment, their potential exposure to radon in flare gas is considered in this assessment.

Although recommended limits regarding exposure to radon are usually expressed in terms of WL and WLM, measurements of radon in flare gases are most easily conducted in terms of radon gas concentrations (in units of pCi/L). This is not a problem, however, because these limits can be converted into radon concentrations. For example, the National Council on Radiation Protection (NCRP, 1993) recommends that remedial action be undertaken when continuous exposure to radon (e.g., in the home) is expected to exceed an annual exposure of 2 WLM. Assuming that a worker could be directly exposed to flare gases for 4 hours per day, 1 day per week, the maximum concentration to which this worker could be exposed (without exceeding the recommended limit) is approximately 340 pCi/L of radon. Thus, as long as the radon concentration is less than 340 pCi/L, and exposures are less than 4 hr/wk, the recommended limit of 2 WLM per year will not be exceeded. This radon concentration is calculated as follows:

2 WLM/yr x (170 hr/mo) / (4 hr/wk x 52 wk/yr) = 1.7 WL

The relationship of WL to radon daughter concentration is: 1 WL = 100 pCi/L of radon daughters (total). As a rule of thumb, the concentration of radon daughters is roughly half of the concentration of radon gas. Therefore, 1.7 WL is equal to 170 pCi/L of radon daughters, which is equivalent to a radon concentration of 340 pCi/L.

The average radon-222 concentration in the main flare is 173 pCi/L (Table 3). The concentrations in the auxiliary flare and active fill area flare are smaller (131 pCi/L and 69 pCi/L, respectively). Since these radon concentrations are less than 340 pCi/L, the recommended exposure level will not be exceeded as long as exposure to flare gas is not significantly greater than 4 hr/wk. In addition, radon is a naturally occurring element which is present in all soils at varying levels. Thus, the presence of radon in the gas collection system does not necessarily suggest that the contaminated soils is the source of the radon.

The results of air particulate data from an employee performing ground maintenance activities (i.e., mowing) at the grounds adjoining Area 1 of the West Lake Landfill, suggest that potential radioactivity in this area is negligible. This may be attributed to the inherent uncertainties that are associated with the analytical data. That is, the errors associated with the gross alpha and gross beta measurements exceed their respective count values (e.g., gross alpha was reported as 0.2 +/- 0.5 pCi/L). Thus, the measurements are not significantly different from zero. Further, the reported gross alpha and beta activities are also less than their respective lower limits of detection.

5.3.1.2 Modeled Radon Concentrations

It is recognized that the combined contributions of three flares and local topographic effects in the very complex landfill terrain could result in concentrations many times greater than the SCREEN exposure model results would indicate. However, the exposure model results are intended to be interpreted qualitatively to evaluate the potential for air quality problems, and not as a fine line between acceptable and unacceptable conditions.

It is accepted practice to estimate the maximum 24-hour concentration by multiplying the maximum one-hour concentration by 0.4 +/- 0.2 (EPA, 1988). While the EPA will not accept extrapolation from one-hour averages to annual averages for purposes of demonstrating regulatory compliance, empirical data produced by the Tennessee Valley Authority indicate that annual average concentrations may be two orders of magnitude less than the observed maximum one-hour concentration (Montgomery and Coleman, 1975).

Consequently, a very conservative estimate of the maximum one-hour average concentration based on the 24-hour average calculated for impaction of the 8-inch utility flare plume on the edge of the cliff would be 0.163 E-02 divided by 2, or 0.00815 pCi/L. Assuming that the maximum one-hour concentration for each flare occurred during the same hour at the same location would result in a combined maximum one-hour concentration of 0.01 pCi/L. Applying even a one-order of magnitude correction to extrapolate from the maximum one-hour concentration to an annual average concentration would result in an estimated annual average concentration of 0.001 pCi/L, or 3½ orders of magnitude below the EPA-recommended 4 pCi/L level.

The salient point to be noted here is that the results of the exposure model indicate that once the 180 picoCuries of radon gas per liter of landfill gas are emitted through the flare and dispersed in the atmosphere, the worst-case one-hour average concentrations are three orders of magnitude below the EPA's recommended 4 pCi/L annual average concentration for homes.

Therefore, based on the SCREEN exposure modeling results, it appears that radon gas concentrations in the ambient air, due to landfill gas emissions from the flares, will not pose a potential air-quality problem.

Radon concentrations measured in picoCuries per liter of air are only indicative of the concentration of radon gas. This is because the concentration of radon gas in air does not reflect the concentration of radon daughters in the air unless the decay products are in equilibrium with the radon gas, or the extent of equilibrium is known. The reason why radon gas is an "indoor air quality" problem is because radon gas emitted outdoors is dispersed by air currents, and is rapidly diffused in the atmosphere. The radon gas concentration may be relatively unchanged due to a constant source. There is, however, constant "turnover" of the radon gas with little, or no possibility for radon daughters to accumulate, or even remotely approach equilibrium with the parent gas.

This is consistent with the fact that in spite of the 5.9 pCi/L of radon gas measured in the ambient air at the landfill (Table 3), workers' exposure levels measured in Working Levels in the same area were all below 0.001 (Table 4). At 50% equilibrium, 5.9 pCi/L corresponds to approximately 0.03 WL, which is slightly in excess of the EPA's 0.02 WL action level. However, the observed radon gas and radon daughter concentrations of 5.9 pCi/L and 0.0047 WL, respectively, correspond to less than 2% radon/daughter equilibrium, which is entirely reasonable for outdoor radon emissions.

When radon is trapped in a poorly ventilated uranium mine, or in a basement, there is sufficient time, however, for the radon to decay to radon daughters which may "build-up" and achieve equilibrium with the parent gas. Thus, the 4 pCi/L radon concentration associated with the EPA's recommended action level of 0.02 WL is, in fact, based upon the assumption that the radon decay products are 50% in equilibrium with the parent radon gas. It should be noted, however, that it is only in this case that 4 pCi/L is equivalent to 0.02 WL.

The highest detected radon daughter concentration (0.0047 WL) at the Bridgeton Site was measured indoors (i.e., in an office). It is appropriate to point out that the EPA's 0.02 WL action level is based upon an assumed 20 "Working Level Months" per year spent in the home, whereas occupational exposure limits are generally based upon 12 Working Level Months. As previously explained, a "Working Level Month" is the equivalent of one month at work (i.e., 170 hours or 40 hours per week for one month) while exposed to a radon daughter concentration of 1.0 WL. Thus, the EPA action level for radon daughters in homes is actually 0.02 WL x 20 months or 0.4 WLM per year. Consequently, if someone were to occupy the office with the 0.0047 WL concentration of radon daughters, for 170 hours per month, the resulting exposure would be 0.0047 x 12, or 0.056 WLM.

Any one of the observations and/or results discussed above would, in itself, offer much in the way of compelling evidence that radon gas emissions do not pose a potential air quality problem at the Bridgeton Landfill. However, certain results if taken out of context or examined in isolation would indicate otherwise. It should be emphasized that the radon gas concentrations measured in both the landfill gas collection system and the ambient air, the SCREEN exposure model emission results, the measured worker exposure levels, and the implied radon-daughter equilibrium levels are all very reasonable and quite consistent.

Thus, it can be concluded from the above discussions that the radon gas emissions from the Bridgeton Landfill Site, whether from the active landfill gas

collection system, or due to passive venting, do not pose a potential threat to Site workers, the general public, or the environment.

5.3.2 Ingestion Dose Estimates

5.3.2.1 Leachate Concentrations

Although leachate is not ingested at the Site, leachate concentrations may be compared to drinking water standards for the purpose of evaluating the potential impact on human health, and to the Metropolitan Sewer District limits for discharge to the sewers to evaluate the potential impact on community water supply systems. The EPA's proposed maximum contaminant levels (MCLs; 40 CFR 141) for radon-222 and radium-226 are, respectively, 300 pCi/L and 20 pCi/L. As indicated in Table 9, the maximum detected radionuclide concentrations in leachate samples are 284 pCi/L (radon-222), 1.4 pCi/L (radium-226), and 84.7 pCi/L (gross beta activity). In both cases, the maximum detected concentrations are less than the proposed MCLs. Gross alpha activity was not detected in the analyzed leachate samples. The results of these analyses clearly indicate that the leachate at the Site will not adversely impact the quality of potable groundwater.

The Metropolitan Sewer District recommended average monthly discharge limit for radium-226 is 600 pCi/L (10 CFR 20). It is noteworthy that by comparison, this limit has not been exceeded by the detected concentrations in leachate samples at the Site (Table 9).

It can, thus, be reasonably concluded that the discharge of contaminated leachate into the sewer system will not pose a potential threat to humans or the environment.

For gross beta activity, the presumptive screen for regulatory compliance is 50 pCi/L in drinking water. The maximum detected gross beta activity of 84.7 pCi/L (Table 9) exceeds this concentration. This is consistent with the findings by the

NRC (1988), that several on-site water samples at the West Lake Landfill, including all the leachate treatment plant samples, exceeded the EPA drinking water action level (50 pCi/L) for gross beta activity. However, this does not pose a direct threat to human health, particularly in the case of reasonably anticipated occupational exposure scenarios, unless someone were to use the landfill leachate as a primary source of drinking water. Furthermore, isotopic analyses have indicated that the beta activity can be attributed to potassium-40 (NRC, 1988). Potassium-40 is a naturally occurring radionuclide which is present in all soils, and is not usually associated with radioactively contaminated soils.

Therefore, it may be reasonably concluded that the contribution of any exogenous radionuclides in the leachate to the (total) impact on human health, is expected to be negligible.

5.3.2.2 Condensate Concentrations

In the case of potential exposure to contaminated condensate at the Bridgeton Landfill, the data of the analyzed radionuclides suggest that potential radioactivity in this medium is negligible because of the associated counting errors reported for gross alpha and radium-226 (Table 10). Further, (according to information received from the laboratory) the sample and duplicate analytical data for these radionuclides are not significantly different from the equipment blank results, based on a 95% statistical confidence level for counting errors.

The gross beta activity in the condensate sample reported at 10.1 +/- 2.4 pCi/L exceeds the detection limit of 3.0 pCi/L, and is also significantly higher than the equipment blank at the 95% confidence level (Table 10). The same is also true for the duplicate sample. Although the presence of beta emitters in the condensate at a concentration higher than the sampling equipment blank was reported; however, this does not suggest that the radioactivity is the result of the contamination at the Site. Rather, this may simply reflect natural radioactivity that is associated with the general geographical location and conditions. In addition, even though condensate is discharged into the leachate lagoon at the Bridgeton Landfill, as noted above, leachate is not ingested at the Site. Further, the EPA drinking water action level (50 pCi/L) for gross beta activity has not been exceeded by measured condensate concentrations at the landfill.

Thus, it may be concluded that the potential exposure to radiologically contaminated condensate at the Bridgeton Site does not pose a threat to human health.

As indicated in Table 10, reported analytical results for radon-222 in the second condensate sample is 244 +/- 123 pCi/L, duplicate is 309 +/- 125 pCi/L, and equipment blank is 295 +/- 126 pCi/L. It can be stated that there appears to be no significant difference between these concentrations because of the associated counting errors.

5.3.2.3 Transferable Radiological Contamination

The "frisking" of Site employees for potential radiological contamination, and the conducting of swipe tests on heavy equipment were intended to evaluate the presence of transferable contamination, which can be a source of incidental ingestion of radionuclides. The results of these surveys (Tables 5 and 7) indicate that transferable contamination is of no major concern. This is not unexpected because the areas of contaminated materials have been well delineated in previous investigations (RMC, 1982; NRC, 1988), and the areas of surface contamination are also small. If personnel and equipment are kept out of Areas 1 and 2, the possibility of personnel contamination will be expected to be negligible as well.

It should, however, be noted that the results of the present surveys clearly indicate that potential transferable contamination at the Bridgeton Site is of no major health concern.

5.3.3 External Radiation Dose Estimates

Field survey data indicate the radiation levels to which employees may be exposed. Table 6 presents the results of the Site external gamma radiation exposure survey, in units of counts per minute (cpm). For the radiation detector that was used in this survey, these data can be converted to dose rate levels (in mrem/hr) by dividing by a conversion factor [200,000 cpm/(mrem/hr)]. Therefore, the maximum detected dose rate (62,400 cpm at Point 16) is 0.3 mrem/hr. Natural background radiation levels at the Site are approximately 0.01 to 0.02 mrem/hr (2,000 to 4,000 cpm). It is important to note that this background dose rate is consistent with natural external background radiation in the United States (EPA, 1981). Only Points 15, 16, and 17 (located across the access road from the Site offices) indicate gamma levels above background (Table 6). This is, however, consistent with the NRC report (1988), which states that only two small regions in Area 1 showed elevated external radiation levels, with both areas located near the access road across from the Site offices.

The NRC has recently conducted surveys within Areas 1 and 2 (Lambert, 1992 and 1993). The results of these surveys indicate that the dose rate in Area 1 ranges from 0.015 to 0.030 mrem/hr, while the average dose rate in Area 2 is 0.10 mrem/hr.

The basic dose limit for the public as recommended by the NCRP (1993) is 100 mrem/yr (continuous exposure) and 500 mrem/yr (infrequent exposure). This recommendation is similar to the standards set by the NRC (10 CFR 20) and DOE (Order 5400.5) for protection of the public. Because of the infrequent exposure in the gamma-contaminated portions of Area 1, the higher of these two limits (500 mrem/yr) is applicable.

Thus, the detected maximum gamma dose rate of 0.03 mrem/hr, which is orders of magnitude below recommended exposure limit, suggests that potential external gamma radiation dose is of no health concern at the Site.

Elevated radiation levels generally indicate that contaminated materials are close to the ground surface. It should be noted that photons (i.e., gamma and X-rays) can impart a radiation dose to internal organs even when the radioactive materials which emit them are outside of the body. However, by maintaining a sufficient distance or shielding from photon-emitting radionuclides, one can significantly reduce or eliminate the potential dose associated with this exposure pathway.

The results of the radiation dosimetry for measurements obtained during mowing activities at the grounds adjoining Area 1 of the West Lake Landfill were reported to be below the detection limit of the dosimeter (i.e., <10 mrem). This suggests that, during the approximately seven hours that the dosimeter was worn, an external gamma radiation exposure was not detected at the Site.

Therefore, in view of the short frequency of exposure during the performance of mowing activities in this area, the potential exposure to adverse levels of gamma radiation is not expected to be of concern at the Bridgeton Landfill.

6.0 CONCLUSIONS

The results of the comprehensive environmental media investigation conducted at the Bridgeton Sanitary Landfill were used to evaluate specific areas which appear to have been impacted by the low-level radioactive wastes deposited in Areas 1 and 2 of the adjacent West Lake Landfill. Elevated radon-222 and gamma radiation levels are mainly at the LFG collection wells located in the northeast portion of the Site, and in the area of the office building situated immediately west of Area 1.

First, the results of the potential health impact assessment at the Site indicate that recent measurements of radon daughter products, to which on-site workers may be potentially exposed via inhalation, are nearly 10 times below the recommended EPA regulatory limit of 0.03 WL for indoor exposure. Furthermore, the results of modeled radon gas emissions in flares at the Site indicate that worst-case one-hour concentrations that are three orders of magnitude below the EPA's recommended 4 pCi/L **annual** average level for homes. Thus, radon gas emissions do not pose a potential threat to Site workers, the general public, or the environment.

Second, although leachate and/or condensate are not ingested at the Site, the potential ingestion of leachate- or condensate-contaminated water by on-site workers was evaluated in this assessment as a worst case exposure scenario. The maximum detected radionuclide concentrations in leachate or condensate samples were found to be less than the EPA proposed maximum contaminant levels (MCL) of 300 pCi/L (radon-222) and 20 pCi/L (radium-226) for drinking water. Furthermore, the detected concentrations in leachate samples were also well below the Metropolitan Sewer District recommended average monthly discharge limit of 600 pCi/L for radium-226.

Third, the results of swipe tests in both office buildings and on heavy equipment at the Site indicate that the incidental ingestion of transferable contamination is not a viable exposure route.

Fourth, the results of the radiation dosimetry for mowing activities at the Bridgeton Site suggest that the potential exposure to adverse levels of gamma radiation should not be of concern. The natural background gamma levels at the Site were found to be generally consistent with natural external background levels in the United States. That is, at points where gamma levels exceeded background, the detected maximum gamma dose rate of 0.03 mrem/hr would result in an annual potential dose to Site workers orders of magnitude below the recommended exposure limit of 500 mrem/yr (infrequent exposure) for the general public.

7.0 RECOMMENDATIONS

Based on the results of the health impact assessment, an extensive ambient air monitoring program and personnel monitoring program equivalent to that required for radiation workers (e.g., periodic whole body counts or personnel radiation exposure dosimetry) is not required at the Bridgeton Sanitary Landfill. However, the following recommendations have been made:

- A limited environmental media investigation should be conducted annually to identify any changes in Site conditions, and any variances from the findings of this report. Such an investigation will also aid in the delineation of the related influences, and extent of potential contamination from the adjacent radioactive depositories at the West Lake Landfill.

- Because the present study is limited to the evaluation of potential radiological contamination, it would be appropriate to evaluate the potential health impact on workers for potential exposure to chemical constituents at the Bridgeton Sanitary Landfill.

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TABLE 1
BRIDGETON LANDFILL HEALTH ASSESSMENT
SAMPLING POINT COORDINATES

Probe #	Northing	Easting
1	1,068,978	516,898
2	1,068,905	516,734
3	1,068,845	516,652
4	1,068,728	516,035
5	1,068,770	516,448
6	1,068,745	516,312
7	1,069,060	516,838
8	1,069,140	516,780
9	1,068,950	516,140
10	1,068,865	516,470
11	1,068,961	516,490
12	1,068,850	516,390
13	1,068,932	516,330
14	1,068,832	516,259
15	1,069,300	516,030
16	1,069,361	516,110
17	1,069,230	515,955
18	1,069,160	515,885
19	1,069,420	516,195
20	1,069,180	515,945
21	1,069,980	515,065
22	1,070,100	515,185
23	1,070,250	515,310
24	1,070,410	515,435
25	1,070,550	515,550

TABLE 2

BRIDGETON LANDFILL HEALTH ASSESSMENT

SUMMARY OF FIELD DATA

MARCH 10-11, 1993

Sample Location	Water Pressure (inches WC)	Methane (% LEL)	Oxygen (%Vol)	Hydrogen Sulfide (ppm)	Radon-222 (pCi/L)	Average Gamma (CPM)
P-1	+6.0	5	NA	NA	-	3,720
P-2	-0.13	21	0.4	2	44.5	4,080
P-3	-3.7	43	0.1	4	17.5	3,780
P-4	-0.13	31	0.8	6	-	3,660
P-5	-0.06	36	6.4	15	1770	3,900
P-6	-0.08	27	1.8	0	73.5	3,720
P-7	NA	20	5.4	45	933	3,480
P-8	0	10	7.4	2	316	3,480
P-9	-0.04	43	0	NA	185	3,840
P-10	0	25	3.4	0	72.4	3,960
P-11	0	29	0.1	4	160	3,540
P-12	NA	40	2.7	9	379	4,080
P-13	+7.4	43	NA	NA	52.4	3,900
P-14	+1.7	43	1.9	15	NA	4,200
P-15	+0.12	50	0.1	0	-	11,700
P-16	-0.07	50	0.7	0	750	43,200
P-17	-	-	-	-	1050	12,000
P-18	0	25	6.5	1	-	4,200
P-19	0	39	13.7	26	997	3,300
P-20	-	-	-	-	NA	4,680
P-21	-	-	-	-	-	2,300
P-22	-	-	-	-	-	2,100
P-23	-	-	-	-	-	2,500
P-24	-	-	-	-	-	2,400
P-25	-	-	-	-	-	2,300
P-26	-	-	-	-	-	2,000
P-27	-	-	-	-	-	8,500
P-28	-	-	-	-	-	1,000
P-29	-	-	-	-	-	2,100
W-1	-2.25	40	0.5	1	218	3,780
W-2	-3.35	45	NA	NA	245	3,660
W-3	-3.6	36	1.4	10	158	3,780
W-4	-3.65	42	NA	NA	196	3,600
W-5	-4.0	42	0.2	10	130	3,960
W-6	-	-	-	-	-	-
W-7	-	-	-	-	-	-
W-8	-6.1	32	NA	NA	-	3,780
W-9	-7.4	40	0.2	9	-	3,480
W-10	-	-	-	-	-	3,420

NOTES:

P-1	=	Probe Number
W-1	=	Well Extraction Number
WC	=	Water Column
% LEL	=	Percent Lower Explosive Limit
ppm	=	Parts per Million
pCi/L	=	Picocuries per Liter
CPM	=	Counts Per Minute
NA	=	Not Analyzed
"-"	=	Sample not taken

TABLE 3
BRIDGETON LANDFILL HEALTH ASSESSMENT
RADON CONCENTRATIONS IN THE LANDFILL FLARE GASES

Location	Sample Identification Number	Concentration (pCi/L)	Average Concentration at Each Sampling Location (pCi/L)
Main Flare	F1	166	173
	F2	181	
	F3	172	
Auxiliary Flare	FS1	157	131
	FS2	171	
	FS3	64.5	
Hole Flare	HF1	66	69
	HF2	70.6	
	HF3	71.5	
Ambient Air		5.9	

TABLE 4
BRIDGETON LANDFILL HEALTH ASSESSMENT
RADON DAUGHTER PRODUCTS MEASUREMENTS USING
THOMSON & NIELSON RADON WORKING LEVEL METERS

Date	Time (initial/ final)	Sampling Time (Ts) (hr)	Location	Instrument Identification Number	Final Reading[1] (alpha counts)	Working Level		Comments
						mWL	WL	
3/10/93	08:50 16:30	7.67	Chevy Pickup-Tim's Truck	8704-61	31	0.69	0.00069	Partly cloudy, windy
3/11/93	09:10 16:32	7.36	Rex 370A Compactor	9808-381	21	0.43	0.00043	Windy, est. 15 mph
3/10/93 to 3/11/93	17:00 07:10	14.17	Mechanics Office Main Building	8704-61	315	3.7	0.0037	Air monitored overnight
3/10/93 to 3/11/93	17:03 07:12	14.15	Employee Breakroom Main Building	8908-381	230	2.34	0.0023	Air monitored overnight
3/11/93	08:08 16:20	8.20	Scale House	8908-381	6	0.11	0.00011	Temperature 28°C, winds 17 mph
3/11/93	08:35 11:00 11:30 16:46	2.42 5.27	Rex Compactor	8704-61	2 12	0.17 0.40	0.00017 0.0004	Instrument accidently turned off. Filter was changed and monitoring reinitiated
3/11/93 to 3/12/93	17:24 07:32	14.13	Westlake Mechanics Shop	8704-61	76	0.89	0.00089	Instrument was placed on a workbench in main portion of building and operated overnight
3/11/93 to 3/12/93	17:26 07:32	14.10	Westlake Mechanics Shop	8908-381	71	0.73	0.00073	Instrument placed on a desk located in the main floor small office and operated overnight

TABLE 4
BRIDGETON LANDFILL HEALTH ASSESSMENT
RADON DAUGHTER PRODUCTS MEASUREMENTS USING
THOMSON & NIELSON RADON WORKING LEVEL METERS

Date	Time (initial/ final)	Sampling Time (Ts) (hr)	Location	Instrument Identification Number	Final Reading[1] (alpha counts)	Working Level		Comments
						mWL	WL	
3/12/93	07:55 14:53	6.97	Main Office Building	8908-381	220	4.7	0.0047	Located on floor underneath the drafting table
3/12/93	08:05 15:35	7.50	D-8 Cat	8704-061	4	0.091	0.00009	The CAT was orginally operating at the demolition dump but was later relocated to the active sanitary landfill operation

[1]Initial instrument reading was zero for all measurements.
[2]Shutdown time is estimated.
Note: Milli working level calculated using $\frac{\text{"Alpha Counts"}}{[(Ts - 0.5) \times CF]}$ as specified by instrument manufacturers.

where Ts is Sampling time ["Final Time" - "Initial Time"]

CF is the conversion factor supplied with each instrument units are CPH/mWL for 1 L/m sampling rate. CF for instrument 8704-061 is 6.3 and CF for instrument 8908-381 is 7.2.

TABLE 5
BRIDGETON LANDFILL HEALTH ASSESSMENT
EMPLOYEE RADIOLOGICAL SURVEY

Employee	Beginning of Shift[1]		End of Shift[2]	
	Average Count Rate (CPM)	Peak Count (CPM)	Average Count Rate (CPM)	Peak Count (CPM)
March 11, 1993				
Employee #1[3]	30s	52	30s	79
Employee #2[3]	30s	77	45	89
Employee #3[3]	30s	78	40s	80
Employee #4[3]	30s	98	40s	72
Employee #5[3]	30s	84	50s	75
Employee #6[4]	30s	84	35	86
Employee #7[3]	30s	52	45	94
Employee #8[3]	30s	92	-[5]	-[5]
Employee #9[6]	40s	90	-	-
March 12, 1993				
Employee #10[7]	45	93	42	92
Employee #11[7]	40	99	42	72
Employee #12[7]	35	94	28	80
Employee #13[7]	32	80	45	71
Employee #14[7]	40	90	38	60
Employee #15[7]	-[8]	-[8]	38	102
Employee #16[9]	42	81	-	-

[1]A few employees were already wearing work clothes when surveyed.
[2]Employees surveyed after end of work shift still wearing their work clothes.
[3]Employees surveyed at 07:30 hrs. and around 16:30 hrs.
[4]Employee was surveyed after having worked onsite for a couple of hours.
[5]Employee was not surveyed at end of work shift.
[6]Room background based on surveys of various locations within the mechanics office.
[7]Employee initially surveyed at shift start between 03:30 and 05:30 hrs., and between 12:30 to 13:15 hrs. at end of work shift.
[8]Employee was not surveyed at beginning of work shift.
[9]Room background based on surveys of various locations within the breakroom.
Note: Instrument used - Eberline ESP-1 rate meter and HP-260 GM (Pancake) probe. Measurements taken with probe between 0.5"-l" from clothing surface.
CPM - Counts Per Minute.

<u>TABLE 6</u>
BRIDGETON LANDFILL HEALTH ASSESSMENT
GAMMA SURFACE MEASUREMENTS

LOCATION	AVERAGE (CPM)	MAXIMUM (CPM)
Control Panel at Main Flare	3,300	4,140
Header Main Flare	3,600	4,020
Point 1	3,720	4,560
Point 2	4,080	4,260
Point 3	3,780	4,620
Point 4	3,660	4,320
Point 5	3,900	4,380
Point 6	3,720	7,680
Point 7	3,480	4,740
Point 8	3,480	4,260
Point 9	3,840	4,560
Point 10	3,960	4,800
Point 11	3,540	4,140
Point 12	4,080	8,640
Point 13	3,900	7,020
Point 14	4,200	5,700
Point 15	11,700	19,020
Point 16	43,200	62,400
Point 17	12,000	17,040
Point 18	4,200	5,400
Point 19	3,300	4,260
Point 20	4,680	7,200
Well 1	3,780	4,860
Well 2	3,660	4,320
Well 3	3,780	5,940

TABLE 6
BRIDGETON LANDFILL HEALTH ASSESSMENT
GAMMA SURFACE MEASUREMENTS (cont.)

LOCATION	AVERAGE (CPM)	MAXIMUM (CPM)
Well 4	3,600	4,440
Well 5	3,960	5,640
Well 8	3,780	5,520
Well 9	3,480	4,200
Well 10	3,420	4,980
NW Corner of Area 1	4,020	4,380
Main gate	2,160	2,820
Westlake Mech Bldg. - SE exterior	1,500	2,000
Westlake Mech Bldg. - SW exterior	1,200	1,400
Westlake Mech Bldg. - NW exterior	1,100	1,300
Westlake Mech Bldg. - NE exterior	1,000	1,200
Blue & White Bldg. - SE exterior	1,500	1,900
Blue & White Bldg. - SW exterior	1,400	1,800
Blue & White Bldg. - NW exterior	1,500	1,800
Blue & White Bldg. - NE exterior	1,700	2,000
Adjacent to Area 2 - Point 21	2,300	2,800
Adjacent to Area 2 - Point 22	2,100	2,300
Adjacent to Area 2 - Point 23	2,500	2,800
Adjacent to Area 2 - Point 24	2,400	2,700
Adjacent to Area 2 - Point 25	2,300	2,500
Adjacent to Area 2 - Point 26	2,000	2,500
Adjacent to Area 2 - Point 27	8,500	20,000
Adjacent to Area 2 - Point 28	1,000	2,000
Adjacent to Area 2 - Point 29	2,100	2,400
Lagoon control panel area	1,800	1,900
Lagoon-dock approach	1,800	2,200

TABLE 6
BRIDGETON LANDFILL HEALTH ASSESSMENT
GAMMA SURFACE MEASUREMENTS (cont.)

LOCATION	AVERAGE (CPM)	MAXIMUM (CPM)
Lagoon-dock	700	900
Lagoon-north bank	1,900	2,200
Lagoon-south bank	2,000	2,200
Lagoon-east bank	1,950	2,200
Lagoon-west bank	1,900	2,200
Lagoon-boat	1,900	2,200
Background level measured approximately 5 miles from landfill	2,300	2,300

CPM - Counts per Minute
Note: Instrument used was an Eberline ESP-1 and gamma scintillation probe. Readings taken with probe held between 6" and 18" above soil surface.

TABLE 7
BRIDGETON LANDFILL HEALTH ASSESSMENT
DETERMINATION OF TRANSFERABLE CONTAMINATION

LOCATION	ALPHA COUNT EVENTS (Count time is 30 sec.)
Locker Room, Locker #22	4
Main Office, Floor Underneath Desk	5
Office Computer Desk	0
Lunch Room, Table	0
C-10 Pickup	0
Office Building, SE Corner, exterior	4
Laidlaw Fuel Truck, Top of Fender, Front Left, Id #144427	0
Laidlaw Waste Oil Truck, Top of Fender, Left Front	0
Laidlaw Mechanics Truck, Top of Fender, Left Front	0
Laidlaw CASE Mini-Front End Loader, Left Front Frame Member	1
REX, Interior, Top of Panel	0
REX, Exterior, Door	1
CAT #973, Adjacent to Lift Controls	2
Westlake Mechanic's Shop, Interior, Top of Metal Locker Door	0
DYNAPAC CA15, Top of Instrument Panel	0
Guard Shack, Exterior, SW Corner	2
Stake 15, Located Parallel to Area 1 Boundary	5
Background (Mechanic's Office Desk)	0
Note: Wipe samples represent amount of transferable contamination per 100 cm^2 area. Samples monitored using an ESP-1 rate meter and alpha scintillation probe.	

TABLE 8A
BRIDGETON LANDFILL HEALTH ASSESSMENT
RADIOACTIVE PARTICULATE MEASUREMENTS FOR
WORKER EXPOSURE DURING MOWING ACTIVITY

Analyte	Concentration (pCi/L)
Gross Alpha, total	0.2
Gross Alpha, total error, +/-	0.5
Gross Alpha, total lower level of detection	0.8
Gross Beta, total	0.5
Gross Beta, total error, +/-	0.9
Gross Beta, total lower level of detection	1.5

TABLE 8B
BRIDGETON LANDFILL HEALTH ASSESSMENT
GAMMA RADIATION EXPOSURE TO
WORKER DURING MOWING ACTIVITY

Date	Time	Location	Results
8/19/93	1:05 to 4:00 pm	Outside of the monitoring area for approximately 15 minutes.	Gamma Radiation Not Detected at Dosimeter Detection Limit of <10 mrem
8/27/93	2:50 to 4:15 pm	Area adjacent to Area 1 (using "brush hog").	
9/7/93	3:50 to 4:50 pm	Area adjacent to Area 1 (using "brush hog").	
9/10/93	3:45 to 5:10 pm	Area adjacent to Area 1 (using "brush hog").	

TABLE 9
BRIDGETON LANDFILL HEALTH ASSESSMENT
LEACHATE SAMPLING RESULTS

Sample Number	Analyte	Concentration (pCi/L)
A1-A	Radon-222	240
A1-Duplicate	Radon-222	284
A1-B	Radon-222	266
Equipment Blank	Radon-222	Below detection limit (206 pCi/L)
2A-1,2,3	Gross Alpha	Below detection limit (19.3 pCi/L)
Equipment Blank	Gross Alpha	Below detection limit (2.0 pCi/L)
2A-1,2,3	Gross Beta	84.7
Equipment Blank	Gross Beta	4.8
2A-1,2,3	Radium-226	1.4
Equipment Blank	Radium-226	Below detection limit (0.6 pCi/L)

TABLE 10
BRIDGETON LANDFILL HEALTH ASSESSMENT
CONDENSATE SAMPLING RESULTS

Analyte	Sample	Duplicate	Equipment Blank	Concentration
First Condensate Sample				
Gross alpha	3.6	Not Detected	Not Detected	pCi/L
Gross alpha, error, +/-	2.6	2.4	1.0	pCi/L
Gross alpha detection limit	3.3	3.2	1.6	pCi/L
Gross beta	10.1	5.4	1.1	pCi/L
Gross beta error, +/-	2.4	2.1	Not Detected	pCi/L
Gross beta detection limit	3.0	2.9	2.5	pCi/L
Radium-226	0.4	Not Detected	Not Detected	pCi/L
Radium-226 error, +/-	0.5	0.5	0.3	pCi/L
Radium-226 detection limit	0.8	0.8	0.5	pCi/L
Second Condensate Sample				
Radon-222	224	309	295	pCi/L
Radon-222 error, +/-	123	125	126	pCi/L
Radon-222 detection limit	197	198	200	pCi/L

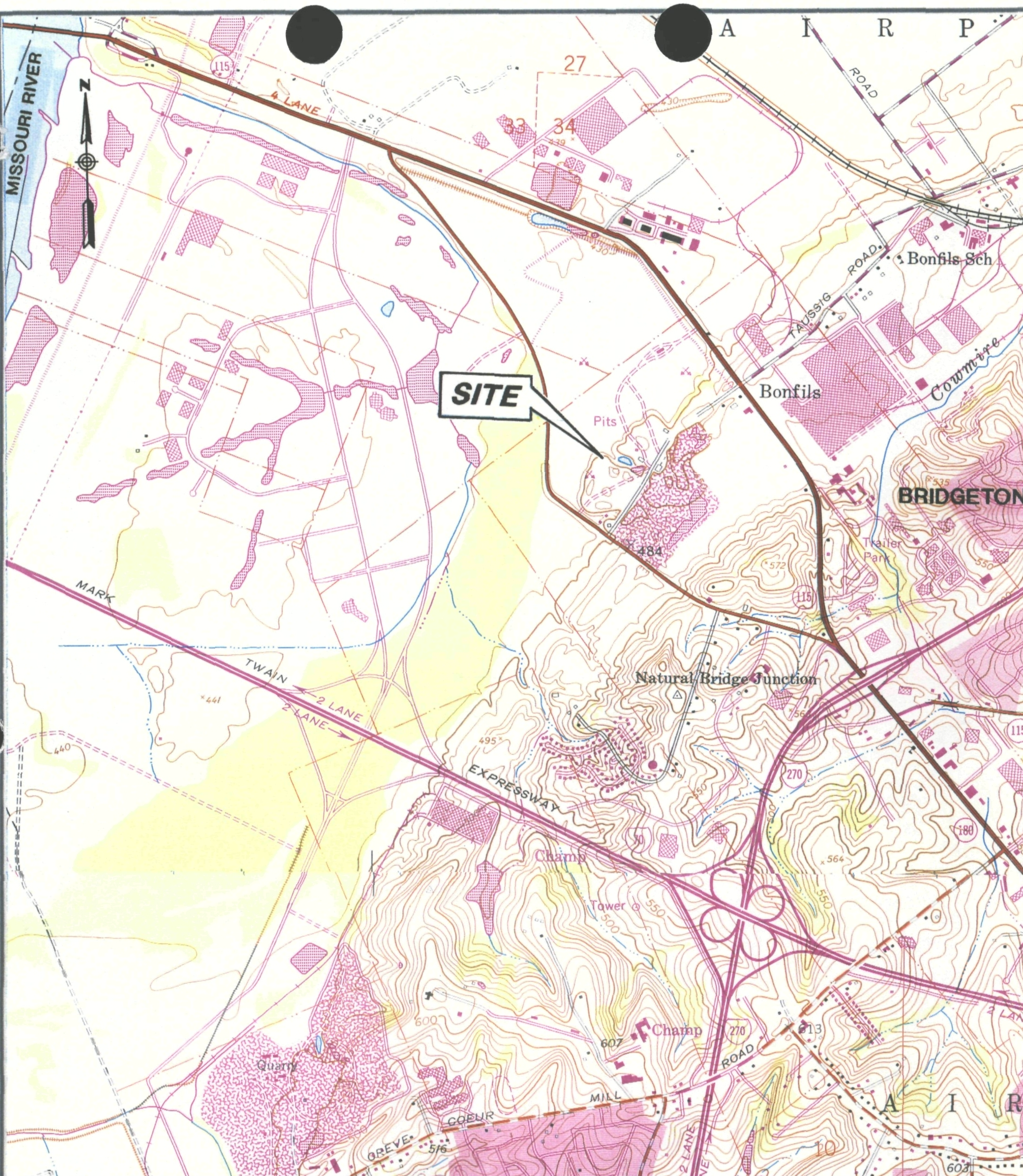
<u>TABLE 11</u>
BRIDGETON LANDFILL HEALTH ASSESSMENT
WIND SPEED AND STABILITY CLASS COMBINATIONS
USED IN THE SCREEN EXPOSURE MODEL

Stability Class	10-meter Wind Speed (m/s) 1	2	3	4	5	8	10	15	20
A	*	*	*						
B	*	*	*	*	*				
C	*	*	*	*	*	*	*		
D	*	*	*	*	*	*	*	*	*
E	*	*	*	*	*				
F (rural only)	*	*	*	*					

TABLE 12
BRIDGETON LANDFILL HEALTH ASSESSMENT
MAXIMUM HOURLY RADON GAS CONCENTRATIONS AND DOWNWIND DISTANCES OBTAINED FROM THE SCREEN EXPOSURE MODEL

	Maximum 1-Hour Conc. (pCi/L)	Downwind Distance to Maximum (Meters)
Main Flare (simple terrain)	0.92×10^{-3}	233
12" Aux. Flare (simple terrain)	0.133×10^{-2}	150
12" Aux. Flare (elevated terrain)	0.178×10^{-2}	129
8" Utility Flare (simple terrain)	0.116×10^{-2}	194
8" Utility Flare (complex terrain)	0.163×10^{-2}*	150

*Maximum 24-hour average concentration at point of plume impaction on edge of cliff.



REFERENCE

TAKEN FROM U.S.G.S., 7.5 MINUTE SERIES TOPOGRAPHIC MAPS, ST. CHARLES AND CREVE COEUR, MISSOURI, PHOTOREVISED 1974

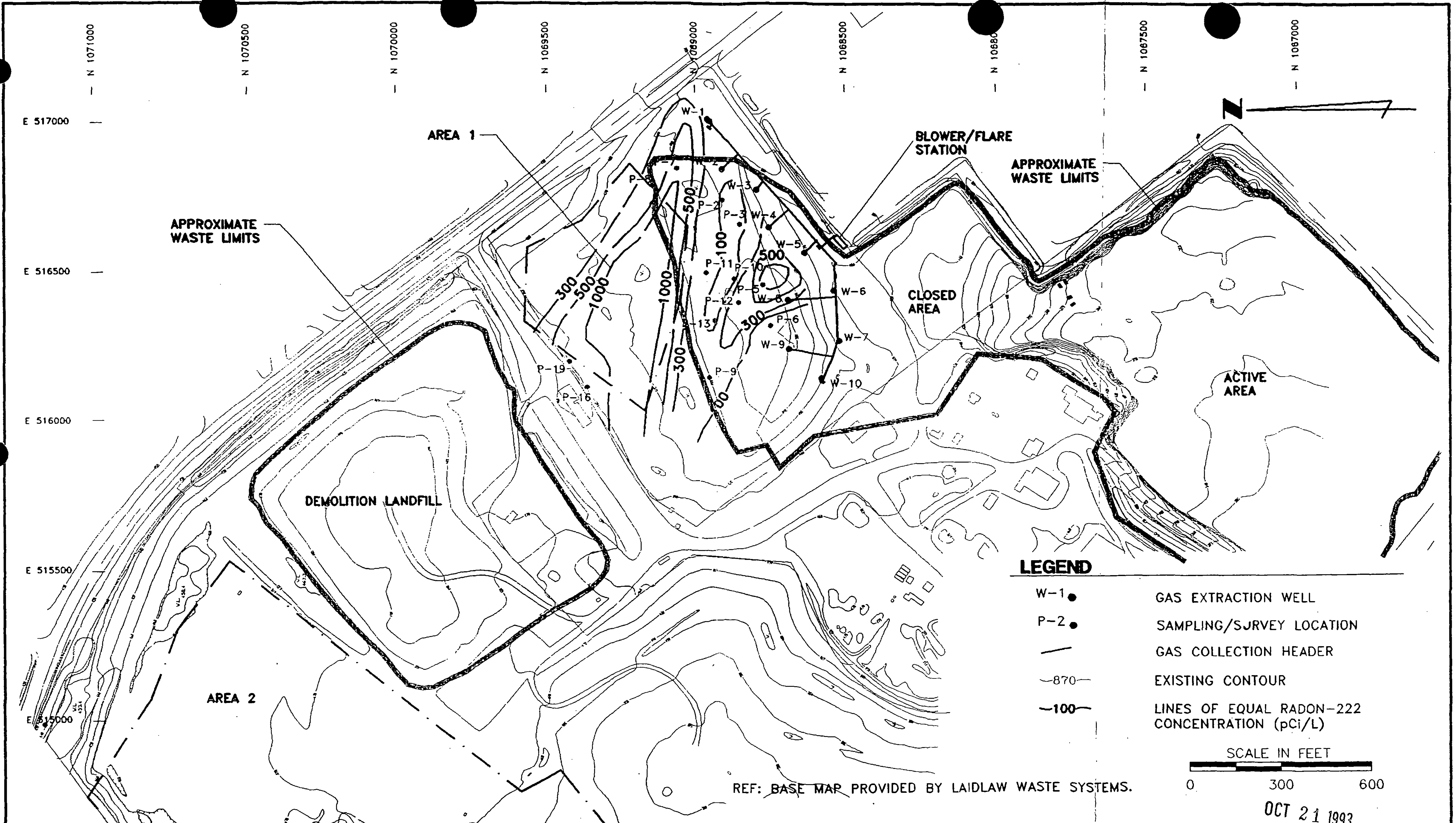
MISSOURI

QUADRANGLE LOCATION

2000 0 2000

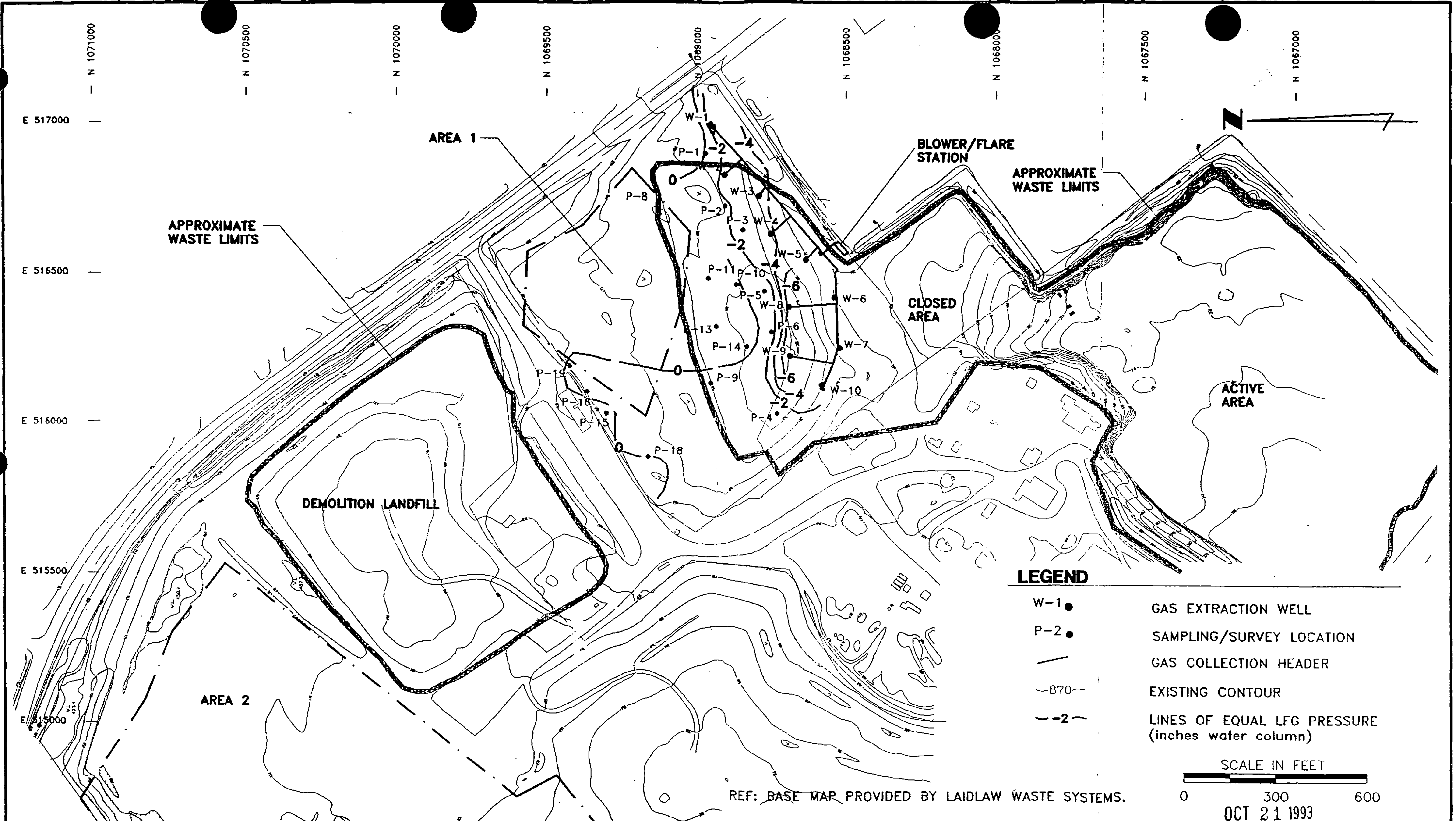
scale feet

JOB No.: 923-6114	SCALE: AS SHOWN	SITE LOCATION MAP	
DR BY: EAM	DATE: 06/03/93		
CHK BY: FA	FILE No.: M001-001		
REV BY: GRF	DR SUBTITLE: 01		
Golder Associates		BRIDGETON SANITARY LANDFILL	FIGURE 1



OCT 21 1993

JOB No.: 923-6114	SCALE: AS SHOWN	INTERPRETED RADON-222 ISO-CONCENTRATION CONTOUR MAP MARCH 1993	
DR BY: EAM	DATE: 10/20/93		
CHK BY: FA	FILE No.: M001-003		
REV BY: GRF	DR SUBTITLE: 01		
Golder Associates		LAIDLAW WASTE SYSTEMS	FIGURE 3



OCT 21 1993

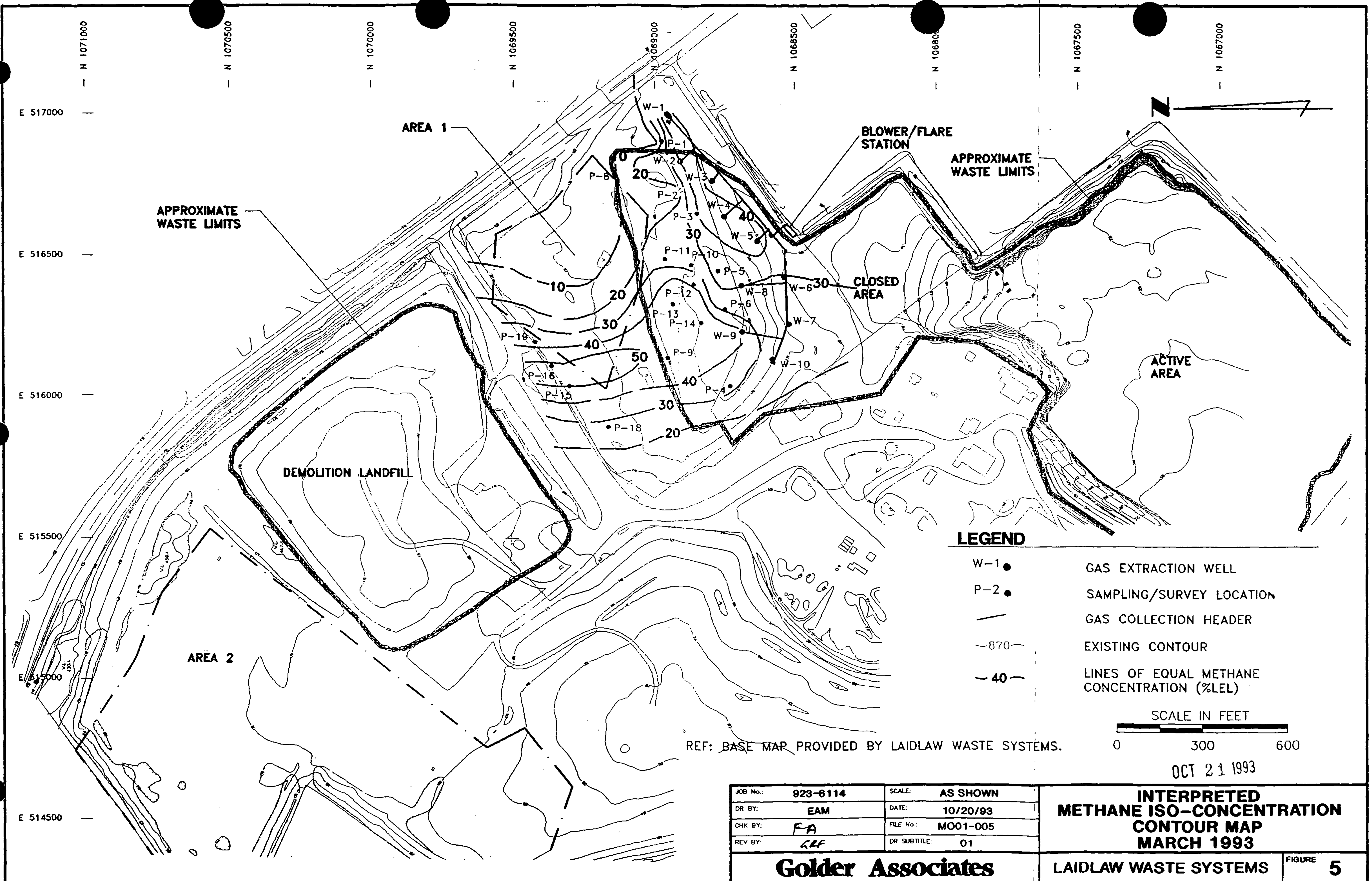
JOB No.:	923-6114	SCALE:	AS SHOWN
DR BY:	EAM	DATE:	10/20/93
CHK BY:	FA	FILE No.:	MO01-004
REV BY:	GRF	DR SUBTITLE:	01

Golder Associates

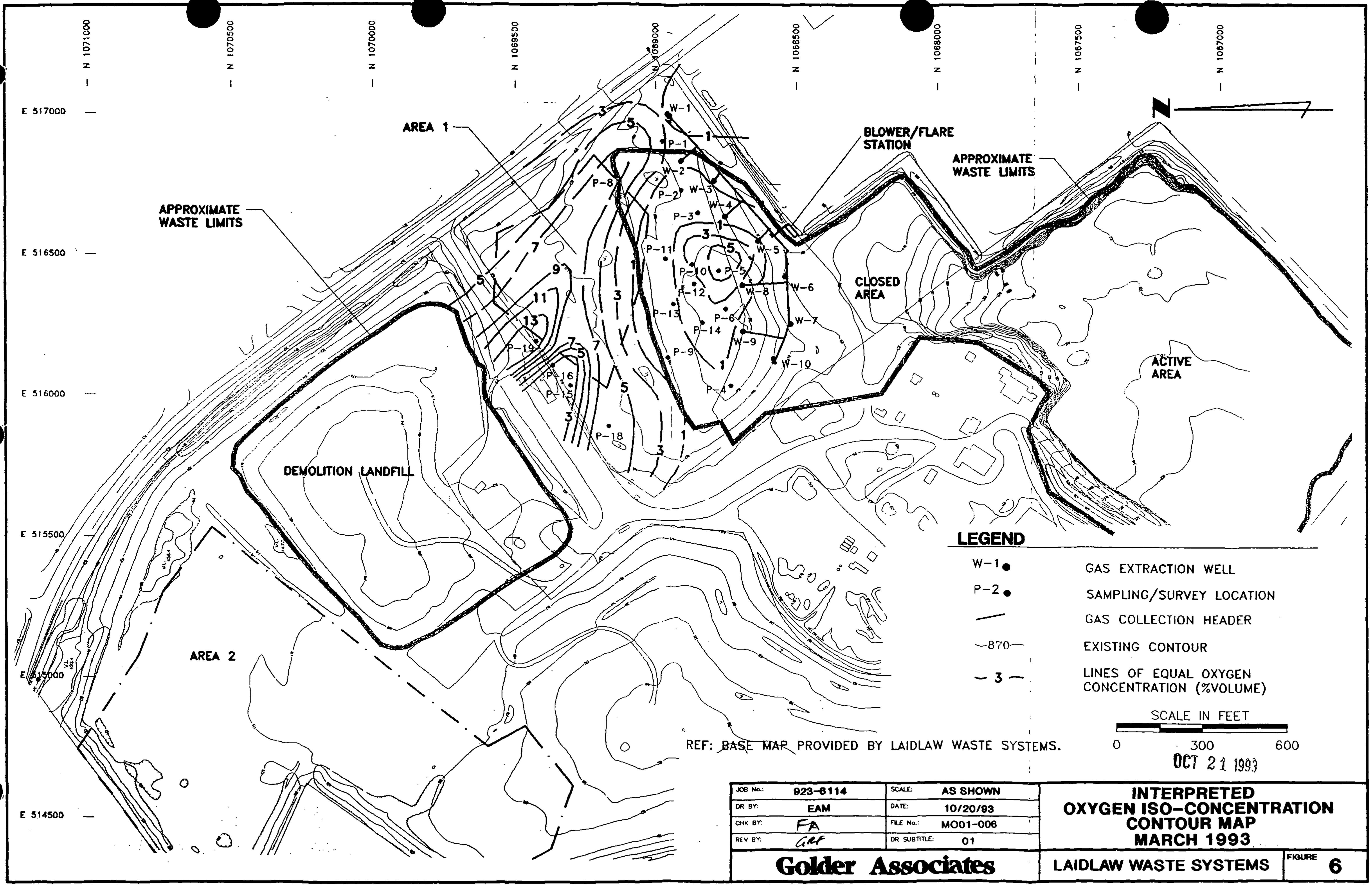
INTERPRETED LFG PRESSURE CONTOUR MAP MARCH 1993

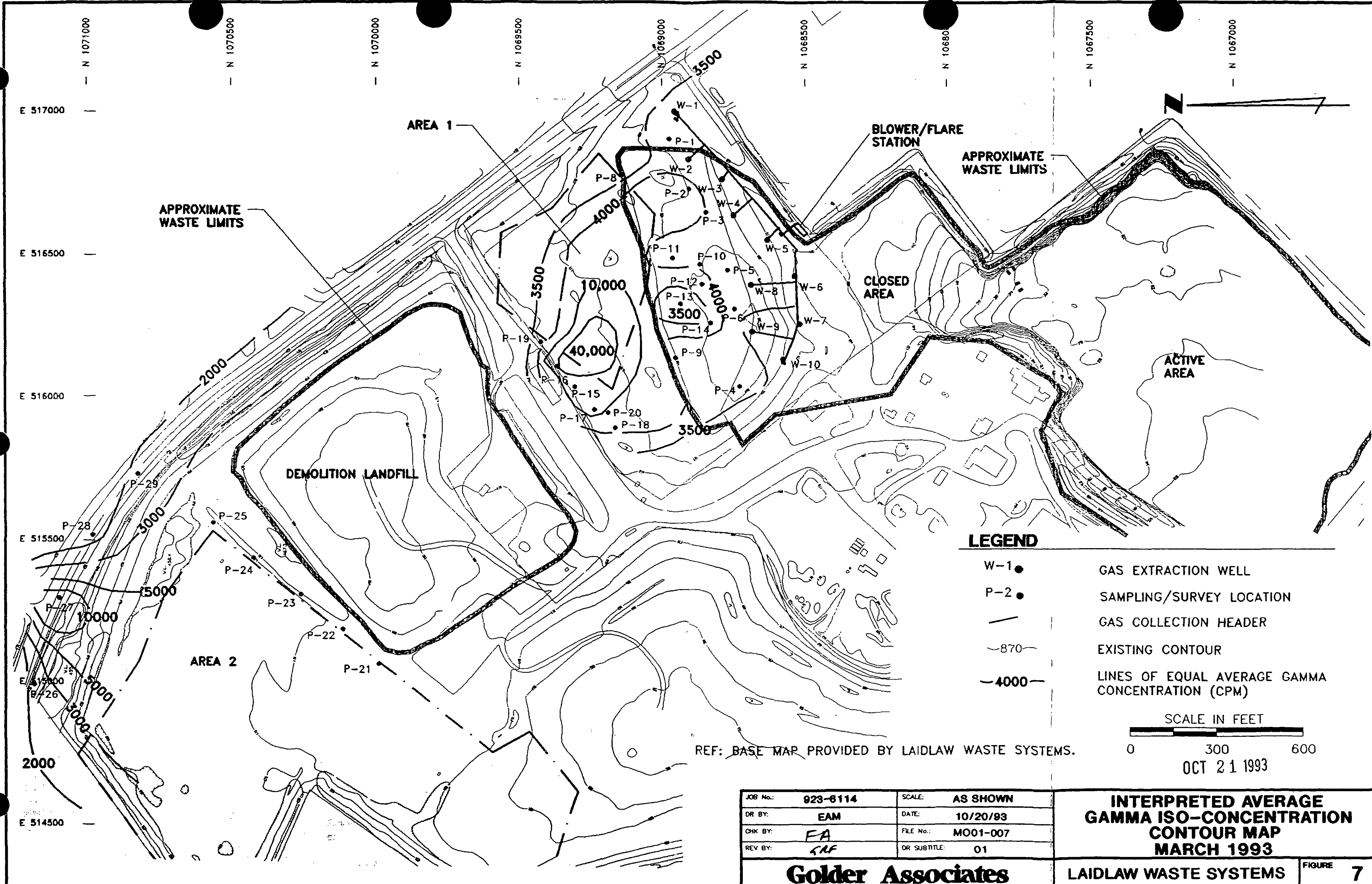
LAIDLAW WASTE SYSTEMS

FIGURE 4



JOB No.: 923-6114	SCALE: AS SHOWN	INTERPRETED METHANE ISO-CONCENTRATION CONTOUR MAP MARCH 1993	
DR BY: EAM	DATE: 10/20/93		
CHK BY: FA	FILE No.: M001-005		
REV BY: GRF	DR SUBTITLE: 01		
Golder Associates		LAIDLAW WASTE SYSTEMS	FIGURE 5


N 1071000
N 1070500
N 1070000
N 1069500
N 1069000
N 1068500
N 1068000
N 1067500
N 1067000
E 517000
E 516500
E 516000
E 515500
E 515000
E 514500
N
AREA 1
APPROXIMATE WASTE LIMITS
BLOWER/FLARE STATION
APPROXIMATE WASTE LIMITS
CLOSED AREA
ACTIVE AREA
DEMOLITION LANDFILL
AREA 2
W-1
W-2
W-3
W-4
W-5
W-6
W-7
W-8
W-9
W-10
P-1
P-2
P-3
P-4
P-5
P-6
P-8
P-9
P-10
P-11
P-12
P-13
P-14
P-15
P-16
P-18
P-19
LEGEND
W-1 GAS EXTRACTION WELL
P-2 SAMPLING/SURVEY LOCATION
GAS COLLECTION HEADER
870 EXISTING CONTOUR
3 LINES OF EQUAL OXYGEN CONCENTRATION (%VOLUME)
SCALE IN FEET
0 300 600
REF: BASE MAP PROVIDED BY LAIDLAW WASTE SYSTEMS.
OCT 21 1993
JOB No.: 923-6114
SCALE: AS SHOWN
DR BY: EAM
DATE: 10/20/93
CHK BY: FA
FILE No.: MO01-006
REV BY: GRF
DR SUBTITLE: 01
INTERPRETED OXYGEN ISO-CONCENTRATION CONTOUR MAP MARCH 1993
Golder Associates
LAIDLAW WASTE SYSTEMS
FIGURE 6



JOB No.:	923-6114	SCALE:	AS SHOWN
DR BY:	EAM	DATE:	10/20/93
CHK BY:	FA	FILE No.:	MO01-007
REV BY:	GRF	DR SUBTITLE:	01

Golder Associates

INTERPRETED AVERAGE GAMMA ISO-CONCENTRATION CONTOUR MAP MARCH 1993

LAIDLAW WASTE SYSTEMS

FIGURE 7

APPENDIX A

REVIEW OF REGULATORY STANDARDS AND GUIDELINES FOR RADIOLOGICAL EXPOSURES

APPENDIX A

REVIEW OF REGULATORY STANDARDS AND GUIDELINES FOR RADIOLOGICAL EXPOSURES

A review of pertinent regulatory standards and guidelines for occupational and public exposure to radioactive materials was conducted. Some of these regulations and guidelines may be applied to the operations at the Laidlaw Waste Systems landfill.

Existing regulations and guidance for allowable exposure levels for radon gas, radon decay products and ionizing radiation were reviewed. The following regulations and guidance documents were reviewed:

National Council on Radiation Protection and Measurements - Recommendations on Limits for Exposure to Ionizing Radiation

29 CFR 1910 Occupational Safety and Health Standards

10 CFR 20 Standards for Protection Against Radiation

Department of Energy Order 5400.5 - Radiation Protection of the Public and the Environment

40 CFR 192 Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings

40 CFR 141 National Primary Drinking Water Standards

40 CFR 61 National Emission Standards for Hazardous Air Pollutants

30 CFR 57 Safety and Health Standards - Underground Metal and Nonmetal Mines

Summary of Regulations and Guidelines

National Council on Radiation Protection and Measurements - Recommendations on Limits for Exposure to Ionizing Radiation

For public exposures from man-made sources, excluding medical and natural background, the NCRP recommends an annual effective dose equivalent of less than 100 mrems. The NCRP recommends that remedial action level for exposure to radon and radon decay products (radon daughter products) should be less than the equivalent of 2 Working Level Months (WLM). One WLM is defined as an average concentration of 4 pCi/L of radon if the radon decay products are in 50% equilibrium with the radon gas, for a period of 170 hours. Working Level (WL) is a commonly used unit of exposure and it refers to the concentration of radon decay products that emit a specific quantity of ionizing radiation when radon daughter products decay.

29 CFR 1910 Occupational Safety and Health Standards

Subpart G of Occupational Health and Environmental Control, Section 1910.96, stipulates ionizing radiation guidelines similar to standards presented in 10 CFR 20. The regulations under this standard establish exposure levels for restricted areas which may not exceed the following levels:

1) 1.25 rems per calendar quarter to the whole body
2) 18.75 rems per calendar quarter to the hand, forearms, feet and ankles
3) 7.5 rems per calendar quarter to the skin of the whole body

Restricted is defined as any area where access is restricted by the employer for the purpose of protecting employees from exposure to radiation. Under these guidelines exposure to an individual does not take into consideration protective clothing, equipment or particle size. The above doses may only be exceeded if the dose to the whole body does not exceed 3 rems in any calendar quarter, and the dose to the whole body when added to the accumulated dose does not exceed 5 rems multiplied by the individuals age minus 18. The employer is required to maintain past and current exposure records to show that doses do not exceed the limit. Calendar quarter is defined as any three month period consisting of 13 consecutive calendar weeks.

The guidelines also stipulate that no employer shall possess, use or transport radioactive material that causes any employee, within a restricted area, to be exposed to airborne radioactive material in average concentrations in excess of the limits established under 10 CFR 20, Table 1 of Appendix B. This applies specifically to employees who are over 18 years of age. The limits established under 10 CFR 20, Table 2 of Appendix B apply to individuals who are less than 18 years of age. The limits given in Table 1 are for exposure to the concentrations specified for 40 hours in any work week of seven consecutive days. For individuals under 18 years of age, concentrations may not be averaged over any period greater than one week. Airborne radon-222 concentrations presented in 10 CFR 20, Tables 1 and 2 of Appendix B are:

- Radon-222 in Table 1, column 1 is $3x10^{-8}$ uCi/mL. The regulatory standard states that a value of 0.33 WL may be substituted.

- Radon-222 exposure limit for individuals under the age of 18 as defined in Table 2 of Appendix B is $3x10^{-9}$ uCi/mL. An alternate value of 0.033 WL may, however, be used.

All employers are required to inform employees working regularly or frequently in any portion of a radiation area of the occurrence of radioactive materials, and also inform employees of safety problems associated with exposure. The employer must inform the employee of precautions and personal protection equipment available to minimize exposure, and shall have available, upon request, copies of these regulations along with operating procedures. Employers shall maintain records for employees that are exposed above 25 % of the applicable allowable values for adults. They are also required to maintain records for minors exposed in excess of 5 % of the above noted limits. Employers shall also advise employees of their exposure rate annually.

10 CFR 20 Standards for Protection Against Radiation

This regulation establishes standards for protection against radiation that may result from occupational exposure at facilities licensed by the Nuclear Regulatory Commission (NRC). This standard does not regulate facilities that are not licensed by the NRC.

Permissible doses, levels, and concentrations are established in Section 20.101 for individuals in restricted areas. Restricted areas means any area where access is restricted by the NRC licensee for the purpose of protection of individuals from exposure to radiation. NRC licensed users of radioactive material shall not allow any individual in a restricted area to receive in any period of one calendar quarter a total occupational dose in excess of:

1) 1.25 rems to the whole body; head and trunk; active blood forming organs; lens of the eyes; or gonads
2) 18.75 rems to the hands, forearms, feet and ankles
3) 7.5 rems to the skin of the whole body

During a calendar quarter the whole body dose shall not exceed 3 rems, and the dose to the whole body when added to the accumulated dose shall not exceed 5 rems multiplied by the individuals age minus 18.

Section 20.103, sets limits for exposure that individuals may receive from concentrations of radioactive materials in air, in restricted areas. NRC licensed users may not allow any individual to inhale a quantity of radioactive radon-222 over the period of one calendar year in excess of the level identified in Appendix B, Table 1, Column 1. The value for radon-222 is $3x10^{-8}$ uCi/mL. The standard states that a value of 0.33 WL may be substituted. When assessment of an individuals intake is necessary, intakes less than those that would result from inhalation for 2 hours in any one day or for 10 hours in any one week at uniform concentrations specified in Table 1, Column 1 of Appendix B need not be included in such assessment, provided that any assessment of exposure in excess of these amounts, the entire duration and quantity of exposure is included.

NRC licensees, as a precautionary procedure shall implement process or engineering controls, to the extent practicable to limit concentrations of radon-222 to 3×10^{-8} uCi/mL in any room. This exposure level applies also to enclosed or operating area, or when averaged over the number of hours in one week during which individuals are present. Further, the concentrations shall not exceed 25% of the radon-222 level of 3×10^{-8} uCi/mL established in Table 1, Column 1, Appendix B.

Section 20.105 sets permissible exposure levels of radiation in unrestricted areas that members of the public may receive as a result of exposure to radioactive material. The standard states that no individual shall receive radiation levels in excess of 0.5 rem over any period of one calendar year; 2 mrems in any one hour if the individual were continuously present; or if the individual were continuously present, would result in receiving an exposure in excess of 100 mrems in any seven consecutive days.

Section 20.106 sets radioactivity levels in effluent released into areas accessible to members of the public. NRC licensees shall not allow the release of radioactive radon-222 to unrestricted areas in excess of 3 pCi/L as defined in Table 2, Column 2, of Appendix B, averaged over a period of not greater than one year. An alternate value of 0.033 WL may be used. These concentration limits apply at the point where the radioactive material discharges from a vent or stack. If the stack discharges in a restricted area the concentration may be measured at the area boundary.

Department of Energy Order 5400.5 - Radiation Protection of the Public and the Environment

The Department of Energy (DOE) has established a system of "Orders" to insure compliance with federal regulations. DOE Order 5400.5 establishes maximum allowable exposures that any member of the public may receive as a result of DOE activities. The DOE order incorporates most of the cleanup and control standards established under EPA's 40 CFR 192 regulations.

The DOE limits are based on a maximum allowable effective dose equivalent of 100 mrems per year. The DOE Order establishes the allowable exposure to members of the public from airborne emissions that result from DOE activities to be less than 10 mrems. This level is established by EPA regulation under the

Clean Air Act in 40 CFR 61, Subpart H. The order establishes limits for radon and its decay products in terms of concentrations Working Levels. The allowable airborne concentration is set at 3 pCi/L. The standard for airborne radon decay products is 0.02 WL in any habitable structure. However, in any case the radon decay product concentration shall not exceed 0.03 WL.

40 CFR 192 Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings

Standards for the Control of Residual Materials from Inactive Uranium Processing Sites, Subpart A, requires that residual radioactive material in tailings piles or stabilized tailings be controlled in a way that provides protection from health hazards associated with uranium tailings. This section specifies that control be effective for up to 1,000 years, to the extent achievable, and in any case no less than 200 years. Control measures are to provide reasonable assurance that releases of residual radioactive material to the atmosphere shall not exceed an average release rate of 20 pCi/m2/sec. Releases of radon-222 shall not cause the radon-222 concentration in ambient to increase greater than 0.5 pCi/L.

Subpart B, Standards for Cleanup of Land and Buildings Contaminated with Residual Materials from Inactive Uranium Processing Sites, applies to land and structures that are part of any site containing residual radioactive materials. Remedial actions at inactive uranium processing sites shall attain to the extent practicable, indoor radon-222 concentrations in any building of less than 0.02 WL, and at no time exceed 0.03 WL. The standard also specifies that indoor gamma radiation shall be less than 20 micro R/hr above background. Cleanup of land surface over any area greater than 100 square meters shall not exceed 5 pCi/g of radium-226 averaged over the first 15 cm of soil below the surface, and 15 pCi/g averaged over 15 cm thick layers below the surface.

40 CFR 141 National Primary Drinking Water Standards

The requirements of the National Primary Drinking Water Standards establish maximum contaminant levels (MCL) allowed in drinking water, as measured at the tap. Current and proposed maximum contaminant levels established for specific radionuclides are presented below:

> **Radon-222** An MCL has not been established; however, an MCL of 300 pCi/L has been proposed.
>
> **Radium-226** The current MCL is 5 pCi/L for a combination of radium-226 and radium-228. An MCL of 20 pCi/L has been proposed for radium-226.

Gross Alpha Activity The current MCL for gross alpha activity is set at 15 pCi/L. A proposed MCL is based on an adjusted gross alpha activity and is set at 15 pCi/L.

Gross Beta Activity The average annual concentration in drinking water shall not produce an annual dose equivalent to the body greater than 4 mrems per year. A proposed MCL of 4 mrems effective dose equivalent per year has been published.

40 CFR 61 National Emission Standards for Hazardous Air Pollutants

The National Emissions Standards for Hazardous Air Pollutants (NESHAPS) establishes standards for the emission of radionuclides including radon. Subpart B establishes annual radon emission limits to the ambient air at levels that would not result in any member of the public from receiving an annual effective dose equivalent of 10 mrems. Subpart Q sets emission limits for radon resulting from Department of Energy facilities. Subpart T sets emission standards for releases of radon resulting from the disposal of uranium mill tailings and Subpart W sets emission standards from operating uranium mill tailings. Subparts Q, T, and W have established the same limit of 20 pCi/m2/s.

30 CFR 57 Safety and Health Standards - Underground Metal and Nonmetal Mines

These regulations address ionizing radiation, including radon decay products and gamma radiation. Air Quality, Radiation, and Physical Agents - Radiation for Underground Mines, Subpart D, specifies that exhaust air from mining operations must be sampled to determine radon daughter concentrations. If radon daughter concentrations in excess of 0.1 WL are found in the exhaust air sample, the employer shall monitor the employee breathing zone for radon decay concentrations every two weeks at random times in all active areas. Where uranium is not mined, the workers breathing zone must be monitored at least every three months until radon decay product concentrations are below 0.1 WL.

Annual exposure limits are not to exceed 4 WLM for any individual, and at no time shall any active worker be exposed above the maximum permissible concentration of 1 WL, unless proper respiratory protection, as defined in the standard, is being used. Areas where radon decay product concentrations exceed 1 WL shall be restricted to authorized personnel only.

APPENDIX B

FIELD AND ANALYTICAL SAMPLING DATA

Western Atlas International
A Litton/Dresser Company

CORE LABORATORIES

CORE LABORATORIES
ANALYTICAL REPORT

Job Number: 930407
Prepared For:

GOLDER ASSOCIATES
KENT ANGELOS
4104 148th AVENUE NE
REDMOND, WA 98052

Date: 03/18/93

Dr. John M. DeHart
Signature

18 Mar 93
Date:

Name: Dr. John M. DeHart

Title: Laboratory Supervisor

Core Laboratories, Inc.
420 West First Street
Casper, WY 82601

Western Atlas International
A Litton/Dresser Company

CORE LABORATORIES

FINAL REPORT DISTRIBUTION

03/18/93

JOB NUMBER: 930407

COMPANY NAME	COMPANY MAILING ADDRESS	COMPANY CITY	STATE	COMPANY ZIP CODE
GOLDER ASSOCIATES KENT ANGELOS	4104 148th AVENUE NE	REDMOND	WA	98052

Western Atlas International
A Litton/Dresser Company

CORE LABORATORIES

LABORATORY TESTS RESULTS
03/18/93

JOB NUMBER: 930407 CUSTOMER: GOLDER ASSOCIATES ATTN: KENT ANGELOS

SAMPLE NUMBER: 1 DATE RECEIVED: 03/11/93 TIME RECEIVED: 09:20 SAMPLE DATE: 03/10/93 SAMPLE TIME: 09:15
PROJECT: A1-A BRIDGETON,923-6114.002 SAMPLE: A1-A BRIDGETON,H2O LEACHATE REM: WATER

SAMPLE NUMBER: 2 DATE RECEIVED: 03/11/93 TIME RECEIVED: 09:20 SAMPLE DATE: 03/10/93 SAMPLE TIME: 09:15
PROJECT: A1-DUP BRIDGETON,923-6114.002 SAMPLE: A1-DUP BRIDGETON,H2O LEACHATE REM: WATER

SAMPLE NUMBER: 3 DATE RECEIVED: 03/11/93 TIME RECEIVED: 09:20 SAMPLE DATE: 03/10/93 SAMPLE TIME: 09:15
PROJECT: A1-B BRIDGETON,923-6114.002 SAMPLE: A1-B BRIDGETON,H2O LEACHATE REM: WATER

SAMPLE NUMBER: 4 DATE RECEIVED: 03/11/93 TIME RECEIVED: 09:20 SAMPLE DATE: 03/10/93 SAMPLE TIME: 09:10
PROJECT: EQUIPMENT BLANK,923-6114.002 SAMPLE: EQUIPMENT BLANK REM: WATER

SAMPLE NUMBER: 5 DATE RECEIVED: 03/11/93 TIME RECEIVED: 09:20 SAMPLE DATE: 03/10/93 SAMPLE TIME: 12:10
PROJECT: F1,923-6114 SAMPLE: F1 REM: GAS

SAMPLE NUMBER: 6 DATE RECEIVED: 03/11/93 TIME RECEIVED: 09:20 SAMPLE DATE: 03/10/93 SAMPLE TIME: 12:15
PROJECT: F2,923-6114 SAMPLE: F2 REM: GAS

TEST DESCRIPTION	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4	SAMPLE 5	SAMPLE 6	UNITS OF MEASURE
Radon 222	240	284	266	173	166	181	pCi/l
Radon 222 error, +/-	129	131	130	129	3.6	3.8	pCi/l
Radon 222 LLD	203	204	205	206	0.9	0.9	pCi/l

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LABORATORY TESTS RESULTS
03/18/93

JOB NUMBER: 930407 CUSTOMER: BOLDER ASSOCIATES ATTN: KENT ANGELOS

SAMPLE NUMBER: 7 DATE RECEIVED: 03/11/93 TIME RECEIVED: 09:20 SAMPLE DATE: 03/10/93 SAMPLE TIME: 12:23
PROJECT: F3,923-6114 SAMPLE: F3 REM: GAS

SAMPLE NUMBER: 8 DATE RECEIVED: 03/11/93 TIME RECEIVED: 09:20 SAMPLE DATE: 03/10/93 SAMPLE TIME: 12:00
PROJECT: FIELD BLANK,923-6114 SAMPLE: FIELD BLANK REM: AMBIENT AIR

SAMPLE NUMBER: 9 DATE RECEIVED: 03/11/93 TIME RECEIVED: 09:20 SAMPLE DATE: 03/10/93 SAMPLE TIME: 13:00
PROJECT: FS-1,923-6114 SAMPLE: FS-1 REM: GAS

SAMPLE NUMBER: 10 DATE RECEIVED: 03/11/93 TIME RECEIVED: 09:20 SAMPLE DATE: 03/10/93 SAMPLE TIME: 13:05
PROJECT: FS-2,923-6114 SAMPLE: FS-2 REM: GAS

SAMPLE NUMBER: 11 DATE RECEIVED: 03/11/93 TIME RECEIVED: 09:20 SAMPLE DATE: 03/10/93 SAMPLE TIME: 13:05
PROJECT: FS-3,923-6114 SAMPLE: FS-3 REM: GAS

SAMPLE NUMBER: 12 DATE RECEIVED: 03/11/93 TIME RECEIVED: 09:20 SAMPLE DATE: 03/10/93 SAMPLE TIME: 09:15
PROJECT: 2A-1,2,3;923-6114.002 SAMPLE: 2A-1,2,3 REM: WATER

TEST DESCRIPTION	SAMPLE 7	SAMPLE 8	SAMPLE 9	SAMPLE 10	SAMPLE 11	SAMPLE 12	UNITS OF MEASURE
Radon 222	172	5.9	157	171	64.5		pCi/l
Radon 222 error, +/-	3.7	0.9	3.5	3.7	2.3		pCi/l
Radon 222 LLD	0.9	0.9	0.9	0.9	0.9		pCi/l
Gross Alpha, total						5.6	pCi/l
Gross Alpha, total, error, +/-						12.3	pCi/l
Gross Alpha, total, LLD						19.3	pCi/l
Gross Beta, total						84.7	pCi/l
Gross Beta, total, error, +/-						13.7	pCi/l
Gross Beta, total, LLD						16.3	pCi/l
Radium 226, total						1.4	pCi/l
Radium 226, total, error, +/-						0.6	pCi/l
Radium 226, total, LLD						0.5	pCi/l

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CORE LABORATORIES

LABORATORY TESTS RESULTS
03/18/93

JOB NUMBER: 930407 CUSTOMER: GOLDER ASSOCIATES ATTN: KENT ANGELOS

SAMPLE NUMBER: 13 DATE RECEIVED: 03/11/93 TIME RECEIVED: 09:20 SAMPLE DATE: 03/10/93 SAMPLE TIME: 09:10
PROJECT: EQUIPMENT BLANK,923-6114.002 SAMPLE: EQUIPMENT BLANK REM: WATER

SAMPLE NUMBER: 14 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: :
PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: WELL 4,LAIDLAW/BRIDGETON LANDFILL/MD REM: LANDFILL GAS

SAMPLE NUMBER: 15 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: :
PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: POINT 19,LAIDLAW/BRIDGETON LANDFILL/MD REM: LANDFILL GAS

SAMPLE NUMBER: 16 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: :
PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: WELL 3,LAIDLAW/BRIDGETON LANDFILL/MD REM: LANDFILL GAS

SAMPLE NUMBER: 17 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: :
PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: POINT 6,LAIDLAW/BRIDGETON LANDFILL/MD REM: LANDFILL GAS

SAMPLE NUMBER: 18 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: :
PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: WELL 5,LAIDLAW/BRIDGETON LANDFILL/MD REM: LANDFILL GAS

TEST DESCRIPTION	SAMPLE 13	SAMPLE 14	SAMPLE 15	SAMPLE 16	SAMPLE 17	SAMPLE 18	UNITS OF MEASURE
Radon 222		196	997	158	73.5	130	pCi/l
Radon 222 error, +/-		5.5	12.2	4.9	3.5	4.5	pCi/l
Radon 222 LLD		1.8	1.8	1.8	1.8	1.8	pCi/l
Gross Alpha, total	0.1						pCi/l
Gross Alpha, total, error, +/-	1.2						pCi/l
Gross Alpha, total, LLD	2.0						pCi/l
Gross Beta, total	4.8						pCi/l
Gross Beta, total, error, +/-	2.0						pCi/l
Gross Beta, total, LLD	2.9						pCi/l
Radium 226, total	0.2						pCi/l
Radium 226, total, error, +/-	0.4						pCi/l
Radium 226, total, LLD	0.6						pCi/l

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CORE LABORATORIES

LABORATORY TESTS RESULTS
03/18/93

JOB NUMBER: 930407 CUSTOMER: GOLDER ASSOCIATES ATTN: KENT ANGELOS

SAMPLE NUMBER: 19 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: 12:20
PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: HOLE FLARE 1,LAIDLAW/BRIDGETON LANDFILL/ REM: LANDFILL GAS

SAMPLE NUMBER: 20 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: 12:20
PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: HOLE FLARE 2,LAIDLAW/BRIDGETON LANDFILL/ REM: LANDFILL GAS

SAMPLE NUMBER: 21 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: 12:20
PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: HOLE FLARE 3,LAIDLAW/BRIDGETON LANDFILL/ REM: LANDFILL GAS

SAMPLE NUMBER: 22 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: :
PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: POINT 14,LAIDLAW/BRIDGETON LANDFILL/MD REM: LANDFILL GAS

SAMPLE NUMBER: 23 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: :
PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: POINT 16,LAIDLAW/BRIDGETON LANDFILL/MD REM: LANDFILL GAS

SAMPLE NUMBER: 24 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: :
PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: POINT 9,LAIDLAW/BRIDGETON LANDFILL/MD REM: LANDFILL GAS

TEST DESCRIPTION	SAMPLE 19	SAMPLE 20	SAMPLE 21	SAMPLE 22	SAMPLE 23	SAMPLE 24	UNITS OF MEASURE
Radon 222	66.0	70.6	71.5	N/A	750	185	pCi/l
Radon 222 error, +/-	3.3	3.4	3.4	N/A	10.6	5.3	pCi/l
Radon 222 LLD	1.8	1.8	1.8	N/A	1.8	1.8	pCi/l

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LABORATORY TESTS RESULTS
03/18/93

JOB NUMBER: 930407 CUSTOMER: GOLDER ASSOCIATES ATTN: KENT ANGELOS

SAMPLE NUMBER: 25 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: :
PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: POINT 8,LAIDLAW/BRIDGETON LANDFILL/MD REM: LANDFILL GAS

SAMPLE NUMBER: 26 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: :
PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: POINT 10,LAIDLAW/BRIDGETON LANDFILL/MD REM: LANDFILL GAS

SAMPLE NUMBER: 27 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: :
PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: POINT 11,LAIDLAW/BRIDGETON LANDFILL/MD REM: LANDFILL GAS

SAMPLE NUMBER: 28 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: :
PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: POINT 7,LAIDLAW/BRIDGETON LANDFILL/MD REM: LANDFILL GAS

SAMPLE NUMBER: 29 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: :
PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: POINT 5,LAIDLAW/BRIDGETON LANDFILL/MD REM: LANDFILL GAS

SAMPLE NUMBER: 30 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: :
PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: POINT 12,LAIDLAW/BRIDGETON LANDFILL/MD REM: LANDFILL GAS

TEST DESCRIPTION	SAMPLE 25	SAMPLE 26	SAMPLE 27	SAMPLE 28	SAMPLE 29	SAMPLE 30	UNITS OF MEASURE
Radon 222	316	72.4	160	933	1770	379	pCi/l
Radon 222 error, +/-	7.0	3.5	5.0	11.9	16.3	7.7	pCi/l
Radon 222 LLD	1.8	1.8	1.8	1.8	1.8	1.8	pCi/l

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LABORATORY TESTS RESULTS
03/18/93

JOB NUMBER: 930407 CUSTOMER: GOLDER ASSOCIATES ATTN: KENT ANGELOS

SAMPLE NUMBER: 31 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: :
PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: POINT 13,LAIDLAW/BRIDGETON LANDFILL/MD REM: LANDFILL GAS

SAMPLE NUMBER: 32 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: :
PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: WELL 2,LAIDLAW/BRIDGETON LANDFILL/MD REM: LANDFILL GAS

SAMPLE NUMBER: 33 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: :
PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: WELL 1,LAIDLAW/BRIDGETON LANDFILL/MD REM: LANDFILL GAS

SAMPLE NUMBER: 34 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: :
PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: POINT 17,LAIDLAW/BRIDGETON LANDFILL/MD REM: LANDFILL GAS

SAMPLE NUMBER: 35 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: :
PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: POINT 20,LAIDLAW/BRIDGETON LANDFILL/MD REM: LANDFILL GAS

SAMPLE NUMBER: 36 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: :
PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: POINT 2,LAIDLAW/BRIDGETON LANDFILL/MD REM: LANDFILL GAS

TEST DESCRIPTION	SAMPLE 31	SAMPLE 32	SAMPLE 33	SAMPLE 34	SAMPLE 35	SAMPLE 36	UNITS OF MEASURE
Radon 222	52.4	245	218	1050	N/A	44.5	pCi/l
Radon 222 error, +/-	3.0	6.2	5.8	12.7	N/A	2.8	pCi/l
Radon 222 LLD	1.8	1.8	1.8	1.8	N/A	1.9	pCi/l

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LABORATORY TESTS RESULTS
03/18/93

JOB NUMBER: 930407 CUSTOMER: GOLDER ASSOCIATES ATTN: KENT ANGELOS

SAMPLE NUMBER: 37 DATE RECEIVED: 03/13/93 TIME RECEIVED: 10:00 SAMPLE DATE: 03/11/93 SAMPLE TIME: :

PROJECT: 923-6114.2/LAIDLAW/BRIDGETON SAMPLE: POINT 3,LAIDLAW/BRIDGETON LANDFILL/MD REM: LANDFILL GAS

TEST DESCRIPTION	SAMPLE 37						UNITS OF MEASURE
Radon 222	17.5						pCi/l
Radon 222 error, +/-	2.0						pCi/l
Radon 222 LLD	1.9						pCi/l

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QUALITY ASSURANCE REPORT
03/18/93

JOB NUMBER: 930407 CUSTOMER: GOLDER ASSOCIATES ATTN: KENT ANGELOS

ANALYSIS				DUPLICATES		REFERENCE STANDARDS		MATRIX SPIKES		
ANALYSIS TYPE	ANALYSIS SUB-TYPE	ANALYSIS I.D.	ANALYZED VALUE (A)	DUPLICATE VALUE (B)	RPD or (|A-B|)	TRUE VALUE	PERCENT RECOVERY	ORIGINAL VALUE	SPIKE ADDED	PERCENT RECOVERY
PARAMETER:Gross Alpha, total REPORTING LIMIT/DF: UNITS:pCi/l				DATE/TIME ANALYZED:03/12/93 20:57 METHOD REFERENCE :EPA 900.0						QC BATCH NUMBER:132263 TECHNICIAN:JG
BLANK	MB	MB1AB0311	ND							
STANDARD	LCS	LCS1A0311	28.9			32.0	90			
SPIKE	MS	930407-13	167					0.1	160	104
DUPLICATE	MD	930407-13	0.1	0.7	150					
PARAMETER:Gross Beta, total REPORTING LIMIT/DF: UNITS:pCi/l				DATE/TIME ANALYZED:03/12/93 21:03 METHOD REFERENCE :EPA 900.0						QC BATCH NUMBER:132266 TECHNICIAN:JG
BLANK	MB	MB1AB0311	ND							
STANDARD	LCS	LCS1B0311	16.6			17.0	98			
SPIKE	MS	930400-3	76.7					ND	85.0	90
DUPLICATE	MD	930407-13	4.8	2.2	74					
PARAMETER:Radon 222 REPORTING LIMIT/DF: UNITS:pCi/l				DATE/TIME ANALYZED:03/13/93 21:46 METHOD REFERENCE :						QC BATCH NUMBER:132303 TECHNICIAN:DF
[illegible]CATE	MD	930407-3	266	261	2					
PARAMETER:Radium 226, total REPORTING LIMIT/DF: UNITS:pCi/l				DATE/TIME ANALYZED:03/18/93 14:34 METHOD REFERENCE :EPA 903.1						QC BATCH NUMBER:132320 TECHNICIAN:NRF
BLANK	MB	MB4R60315	ND							
STANDARD	LCS	LC2R60315	15.2			15.0	101			
SPIKE	MS	930421-1	104					68.9	37.5	94
DUPLICATE	MD	930404-2	1.8	1.8	0					

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QUALITY ASSURANCE FOOTER

03/18/93

NC = Not Calculable due to values lower than the detection limit
ND = Not detected at level in limits column

(1) EPA 600/4-79-020, Methods for Chemical Analysis of Water and Wastes, March 1983
(2) EPA SW-846, Test Methods for Evaluating Solid Waste, Third Edition, November 1986
(3) Standards Methods for the Examination of Water and Wastewater, 16th, 1985
(4) EPA/6004-80-032, Prescribed Procedures for Measurement of Radioactivity in Drinking Water, August 1980
(5) Federal Register, Friday, October 26, 1984 (40 CFR Part 136)
(6) EPA 600/8-78-017, Microbiological Methods for Monitoring the Environment, December 1978
NOTE - Data reported in QA report may differ from values on data page due to dilution of sample into analytical ranges.
NOTE - The "TIME ANALYZED" as indicated in the QA Report may not reflect the actual time of analysis.
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A N A L Y T I C A L   R E P O R T

Job Number: 931154
Prepared For:

GOLDER AND ASSOCIATES
JOE ECKHOFF
4104 148TH AVENUE NE
REDMOND, WA 98052

Date: 07/19/93

Dr. John M. DeHart
Signature

20 Jul 93
Date:

Name: Dr. John M. DeHart

Core Laboratories, Inc.
420 West First Street
Casper, WY 82601

Title: LABORATORY SUPERVISOR

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LABORATORY TESTS RESULTS
07/19/93

JOB NUMBER: 931154 CUSTOMER: GOLDER AND ASSOCIATES ATTN: JOE ECKHOFF

SAMPLE NUMBER: 1 DATE RECEIVED: 06/28/93 TIME RECEIVED: 09:31 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: LAIDLAW-BRIDGETON, MO LANDFILL SAMPLE: CONDENSATE REM: WATER

SAMPLE NUMBER: 2 DATE RECEIVED: 06/28/93 TIME RECEIVED: 09:31 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: LAIDLAW-BRIDGETON, MO LANDFILL SAMPLE: DUPLICATE REM: WATER

SAMPLE NUMBER: 3 DATE RECEIVED: 06/28/93 TIME RECEIVED: 09:31 SAMPLE DATE: / / SAMPLE TIME: :
PROJECT: LAIDLAW-BRIDGETON, MO LANDFILL SAMPLE: EQUIPMENT BLANK REM: WATER

SAMPLE NUMBER: 4

	Sample	Duplicate	Equipment Blank				
TEST DESCRIPTION	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4			UNITS OF MEASURE
Radon 222	1230	815	1110				pCi/l
Radon ~~222 error, +/-~~	425	419	432				pCi/l
Radon 222 LLD	667	672	683				pCi/l
Gross Alpha, total	3.6	3.1	0.4				pCi/l
Gross Alpha, total, error, +/-	2.6	2.4	1.0				pCi/l
Gross Alpha, total, LLD	3.3	3.2	1.6				pCi/l
Gross Beta, total	10.1	5.4	1.1				pCi/l
Gross Beta, total, error, +/-	2.4	2.1	1.5				pCi/l
Gross Beta, total, LLD	3.0	2.9	2.5				pCi/l
Radium 226, total	0.4	ND	ND				pCi/l
Radium 226, total, error, +/-	0.5	0.5	0.3				pCi/l
Radium 226, total, LLD	0.8	0.8	0.5				pCi/l

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QUALITY ASSURANCE REPORT
07/19/93

JOB NUMBER: 931154 CUSTOMER: GOLDER AND ASSOCIATES ATTN: JOE ECKHOFF

ANALYSIS				DUPLICATES		REFERENCE STANDARDS		MATRIX SPIKES		
ANALYSIS TYPE	ANALYSIS SUB-TYPE	ANALYSIS I.D.	ANALYZED VALUE (A)	DUPLICATE VALUE (B)	RPD or (|A-B|)	TRUE VALUE	PERCENT RECOVERY	ORIGINAL VALUE	SPIKE ADDED	PERCENT RECOVERY
PARAMETER:Gross Alpha, total REPORTING LIMIT/DF: UNITS:pCi/l				DATE/TIME ANALYZED:07/06/93 14:54 METHOD REFERENCE :EPA 900.0				QC BATCH NUMBER:136040 TECHNICIAN:JG		
BLANK	MB	MB2AB0702	ND							
STANDARD	LCS	LCS1A0702	30.0			34.0	88			
SPIKE	MS	931154-3	147					0.4	170	86
DUPLICATE	MD	931154-1	3.6	4.7	27					
PARAMETER:Gross Beta, total REPORTING LIMIT/DF: UNITS:pCi/l				DATE/TIME ANALYZED:07/06/93 15:01 METHOD REFERENCE :EPA 900.0				QC BATCH NUMBER:136044 TECHNICIAN:JG		
BLANK	MB	MB2AB0702	1.0							
STANDARD	LCS	LCS1B0702	22.8			24.0	95			
SPIKE	MS	931154-2	117					5.4	120	93
DUPLICATE	MD	931154-1	10.1	7.3	32					
PARAMETER:Radium 226, total REPORTING LIMIT/DF: UNITS:pCi/l				DATE/TIME ANALYZED:07/08/93 11:02 METHOD REFERENCE :EPA 903.1				QC BATCH NUMBER:136382 TECHNICIAN:DW		
BLANK	MB	MB2R60706	0.1							
STANDARD	LCS	LC1R60706	57.8			60.0	96			
SPIKE	MS	930990-9	71.5					2.8	60.0	115
DUPLICATE	MD	930990-53	6.1	7.4	19					
PARAMETER:Radon 222 REPORTING LIMIT/DF: 1 UNITS:pCi/l				DATE/TIME ANALYZED:07/08/93 13:07 METHOD REFERENCE :				QC BATCH NUMBER:136446 TECHNICIAN:NRF		
DUPLICATE	MD	931154-2	815	882	8					

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QUALITY ASSURANCE FOOTER
07/19/93

NC = Not Calculable due to values lower than the detection limit
ND = Not detected at level in limits column
* in the "TECHN" column signifies that the analysis was performed by a subcontract laboratory

(1) EPA 600/4-79-020, Methods for Chemical Analysis of Water and Wastes, March 1983
(2) EPA SW-846, Test Methods for Evaluating Solid Waste, Third Edition, November 1986
(3) Standards Methods for the Examination of Water and Wastewater, 16th, 1985
(4) EPA/6004-80-032, Prescribed Procedures for Measurement of Radioactivity in Drinking Water, August 1980
(5) Federal Register, Friday, October 26, 1984 (40 CFR Part 136)
(6) EPA 600/8-78-017, Microbiological Methods for Monitoring the Environment, December 1978
NOTE - Data reported in QA report may differ from values on data page due to dilution of sample into analytical ranges.
NOTE - The "TIME ANALYZED" as indicated in the QA Report may not reflect the actual time of analysis.
The "DATE ANALYZED" is the actual date of analysis.

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FAX NUMBER: ____________________

Date: 9-27-93

This transmission consists of 3 pages, including cover.

FOR: [illegible]

COMPANY: GOLDER & ASSOCIATES

FROM: Kelley L Schultz

CORE LABORATORIES
A Division of Western Atlas International
420 West First Street
Casper, Wyoming 82601

(307)-235-5741
Fax Number (307)266-1676

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CORE LABORATORIES

LABORATORY TESTS RESULTS
09/27/93

JOB NUMBER: 931552 CUSTOMER: GOLDER AND ASSOCIATES ATTN: JOE ECKHOFF

CLIENT I.D.........: BRIDGETON LAIDLAW/MO
DATE SAMPLED.......: 08/19/93
TIME SAMPLED.......: :
WORK DESCRIPTION...: AREA 1-S1

LABORATORY I.D...: 931552-0001
DATE RECEIVED....: 08/20/93
TIME RECEIVED....: 09:17
REMARKS..........: FILTER

TEST DESCRIPTION	FINAL RESULT	DETECTION LIMIT	UNITS OF MEASURE	TEST METHOD	DATE	TECHNICIAN
Gross Alpha, total	0.2		pCi/filter	EPA 900.0	08/25/93	JG
Gross Alpha, total, error, +/-	0.5		pCi/filter		08/25/93	JG
Gross Alpha, total, LLD	0.8		pCi/filter		08/25/93	JG
Gross Beta, total	0.5		pCi/filter	EPA 900.0	08/25/93	JG
Gross Beta, total, error, +/-	0.9		pCi/filter		08/25/93	JG
Gross Beta, total, LLD	1.5		pCi/filter		08/25/93	JG

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QUALITY CONTROL REPORT
09/27/93

JOB NUMBER: 931552 CUSTOMER: GOLDER AND ASSOCIATES ATTN: JOE ECKHOFF

ANALYSIS				DUPLICATES		REFERENCE STANDARDS		MATRIX SPIKES		
ANALYSIS TYPE	ANALYSIS SUB-TYPE	ANALYSIS I.D.	ANALYZED VALUE (A)	DUPLICATE VALUE (B)	RPD or (|A-B|)	TRUE VALUE	PERCENT RECOVERY	ORIGINAL VALUE	SPIKE ADDED	PERCENT RECOVERY
PARAMETER: Gross Alpha, total REPORTING LIMIT/DF: UNITS: pCi/l				DATE/TIME ANALYZED: 08/25/93 16:39 METHOD REFERENCE: EPA 900.0				QC BATCH NUMBER: 138296 TECHNICIAN: JG		
BLANK	MB	MB4AB0823	ND							
STANDARD	LCS	LCS2A0823	33.2			34.0	98			
SPIKE	MS	931527-2	150					1.3	170	87
DUPLICATE	MD	931542-1	2.6	0.2	171					
PARAMETER: Gross Beta, total REPORTING LIMIT/DF: UNITS: pCi/l				DATE/TIME ANALYZED: 08/25/93 16:45 METHOD REFERENCE: EPA 900.0				QC BATCH NUMBER: 138290 TECHNICIAN: AG		
BLANK	MB	MB4AB0823	1.0							
STANDARD	LCS	LCS2B0823	21.4			24.0	89			
SPIKE	MS	931527-1	113					2.0	120	92
DUPLICATE	MD	931542-1	1.9	1.3	37					

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FAX NUMBER: ____________________

Date: 9-27-93

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FOR: [redacted]

COMPANY: GOLDER & ASSOCIATES

FROM: Kelley L. Stultz

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420 West First Street
Casper, Wyoming 82601

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Fax Number (307)266-1676

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PRELIMINARY REPORT

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L A B O R A T O R Y   T E S T S   R E S U L T S
09/27/93

JOB NUMBER: 931549   CUSTOMER: GOLDER AND ASSOCIATES   ATTN: JOE ECKHOFF

CLIENT I.D.........: LAIDLAW BRIDGETON LANDFILL	LABORATORY I.D...: 931549-0001
DATE SAMPLED.......: 08/20/93	DATE RECEIVED....: 08/23/93
TIME SAMPLED.......: 13:20	TIME RECEIVED....: 08:20
WORK DESCRIPTION...: 8-1	REMARKS..........: WATER

TEST DESCRIPTION	FINAL RESULT	DETECTION LIMIT	UNITS OF MEASURE	TEST METHOD	DATE	TECHNICIAN
Radon 222	244	1	pCi/l		09/27/93	KLS
Radon 222 error, +/-	123		pCi/l		09/27/93	KLS
Radon 222 LLD	197		pCi/l		09/27/93	KLS

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LABORATORY TESTS RESULTS
09/27/93

JOB NUMBER: 931549 CUSTOMER: GOLDER AND ASSOCIATES ATTN: JOE ECKHOFF

CLIENT I.D.........: LAIDLAW BRIDGETON LANDFILL
DATE SAMPLED.......: 08/20/93
TIME SAMPLED.......: 13:10
WORK DESCRIPTION...: DUPLICATE

LABORATORY I.D...: 931549-0002
DATE RECEIVED....: 08/23/93
TIME RECEIVED....: 08:20
REMARKS..........: WATER

TEST DESCRIPTION	FINAL RESULT	DETECTION LIMIT	UNITS OF MEASURE	TEST METHOD	DATE	TECHNICIAN
Radon 222	309	1	pCi/l		09/27/93	KLS
Radon 222 error, +/-	125		pCi/l		09/27/93	KLS
Radon 222 LLD	198		pCi/l		09/27/93	KLS

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CORE LABORATORIES

LABORATORY TESTS RESULTS
09/27/93

JOB NUMBER: 931549 CUSTOMER: GOLDER AND ASSOCIATES ATTN: JOE ECKHOFF

CLIENT I.D.........: LAIDLAW BRIDGETON LANDFILL
DATE SAMPLED.......: 08/20/93
TIME SAMPLED.......: 13:12
WORK DESCRIPTION...: EQUIPMENT BLANK

LABORATORY I.D...: 931549-0003
DATE RECEIVED....: 08/23/93
TIME RECEIVED....: 08:20
REMARKS..........: WATER

TEST DESCRIPTION	FINAL RESULT	DETECTION LIMIT	UNITS OF MEASURE	TEST METHOD	DATE	TECHNICIAN
Radon 222	295	1	pCi/l		09/27/93	KLS
Radon 222 error, +/-	126		pCi/l		09/27/93	KLS
Radon 222 LLD	200		pCi/l		09/27/93	KLS

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SENT BY:SEATTLE ;10-[illegible]-93 ; 9:31AM ; GOLDER ASSOC[illegible] 609 273 0778;# 2/ 3

ACCOUNT NO.	SERIES CODE
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DSIMETRY REPORT

OCESSING 1 - PR 5250 - 8591

ME	SOCIAL SECURITY NUMBER	NOTE (SEE REVERSE SIDE)	DOSIMETER TYPE	USE	RADIATION QUALITY	EXPOSURE TO BADGE (MILLIREMS) FOR PERIOD(S) INDICATED BELOW: DEEP	SHALLOW	CUMULATIVE TOTALS (MILLIREMS): CALENDAR QUARTER: DEEP	SHALLOW	YEAR TO DATE: DEEP	SHALLOW	PERMANENT: DEEP	SHALLOW	ADJUSTMENTS	UNUSED PART OF PERMISSIBLE ACCUMULATED DOSE (MILLIREMS)	SEX	BIRTH DATE: MO	DA	YR	NUMBER BADGE REPORTS: TO DATE	QTR.
SURE PERIOD 08/17/93																					
[illegible]	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]		[illegible]			[illegible]	
			K1			[illegible]	[illegible]					NOTOTAL									
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[illegible]	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					[illegible]			[illegible]	

3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

IGHT WRIST T-OTHER EXTREMITY
EFT WRIST 8-OTHER WHOLE BODY
9-MONITOR

AN "H" (HIGH ENERGY) DESIGNATION, WHEN ONLY LOW ENERGY EXPOSURE IS POSSIBLE, MAY INDICATE THAT THE FILM PACKET WAS EXPOSED OUT OF THE FILTERED HOLDER.

IMPORTANT: SEE REVERSE SIDE FOR ADDITIONAL EXPLANATIONS

2068825498 10-11-93 12:43PM P002 #34

DER ASSOC
ATTN JOE ECK
4104 148TH A
REDMOND

RADIATION D

EMERGENCY PR

PARTICIPANT ID NUMBER	NA
	FOR EXPO
00000	
99001	

1 — 2

LSE CODE (COLUMN 4)
1-WHOLE BODY 3-RIGHT FINGER 5-
2-LENS OF EYE 4-LEFT FINGER 6-

FORM NO. 132-14 (REV. 2/91)

w dose equivale
amount of radiation
was exposed. The
exposed the badge
nd quantity to that
of the body on

th the shipment of
ne radiation doses
d be stored in a
period. The control
rom the dosimeter
o include a control
ent of dosimeters
posure to radiation
lected in the parti-

ORTED

onitoring period be-
ity are recorded as
antity depends on
diation. GARDRAY*
minimum reporting
rays and 40mrem
Y* film dosimeters
mrem. All fast and
s have a minimum
meters for thermal
ose of 10mrem.

of the readings of
and reported to
as zero. Calendar
y conform to NRC
considering starting
chosen.

ATA

information for re-
other regulatory
ve totals may have
ng the totals from
ndments are made
presentative of the
upplementary data
exposure originally
either overstate or
badge assignee.
dition of previous
use of the partic-
may also be re-

ALENTS

lent from all radia-
cm²) in soft tissue.
up and attenuation
d using the 30cm
material specified
n Radiation Units
e equivalent is the
at approximately
tissue. Similar to
shallow dose equiv-
the body is con-
considered equiv-
e shallow dose as
of the whole body.

posures to x or
shallow value re-
f the x or gamma
may or may not be
same value is re-
e equivalent. Beta
hallow dose equiv-

When the lens of the eyes are not sufficiently protected from radiation, NRC Form 5 states that doses at 300mg/cm² or less should be measured. When dosimeter data indicate that reporting the dose at 1cm depth would not reflect the appropriate dose at 0.3cm depth (300mg/cm²) the deep dose reported will be the dose at 0.3cm depth rather than at 1.0cm depth.

7. RING BADGE READINGS

Ring badge readings are reported as a shallow dose as if due to gamma rays. If produced by low energy x-rays or beta particles, the reported value may be incorrect. Calibration factors for x-rays and beta particles are available so that a more accurate interpretation is possible.

8. GENERAL RADIATION EXPOSURE GUIDES*

TYPE OF EXPOSURE	GUIDE VALUE
Whole body; head & trunk; blood forming organs; lens of eye; or gonads	1250 millirems per quarter; 5000 millirems per year. Up to 3000 millirems is permitted in a calendar quarter as long as the accumulated occupational dose to the whole body does not exceed 5000 millirems x (age-18)
Skin of whole body	7,500 millirems per quarter
Hand, forearms, feet and ankles	18,750 millirems per quarter

*U.S.N.R.C. regulations, Title 10, Part 20, Code of Federal Regulations (9-1-78). NOTE: Certain states and other regulatory agencies may follow guides that are different from the above.

COLUMN REFERENCES

NOTES (COLUMN 4)

A ABSENT

B-1 This film appears to have been damaged by light. The accuracy of any reading given would be affected thereby.

B-2 This film appears to have been damaged by moisture. The accuracy of any reading given would be affected thereby.

B-3 This film appears to have been damaged by chemical fogging. The accuracy of any reading given would be affected thereby.

B-4 This dosimeter appears to have been manufactured faultily. The accuracy of any reading given would be affected thereby.

B-5 This film appears to have been damaged by heat or pressure. The accuracy of any reading given would be affected thereby.

C Evidence of contamination.

DA This film packet appears to have been exposed out of the badge, therefore, the value given is based on a high energy gamma calibration and is valid only if the exposure were due to high energy gamma. If it were due to beta particles, or lower energy x or gamma rays, the value reported may be inaccurate.

DC This film packet is partially lightstruck. There is apparently a dose recorded, however, no exact quantitative determination can be made. The reported dose is the maximum received.

DD This film badge appears to have been shielded during exposure. The dose reported is not an exact quantitative determination, but only an indication that the badge was exposed.

DE This film badge appears to have been shielded during exposure. No quantitative determination can be made.

DF This film packet appears to have been misplaced in the badge. The dose reported is not an exact quantitative determination, but is only an indication that the badge was exposed.

DG Although this film packet was slightly lightstruck, there seems to be no apparent effect on the reading.

DH The beta-gamma background on this film badge was too high to give a valid fast neutron reading.

DI This reading is based on 50-150KV x-ray. This film badge appears to be defective; please return holder for replacement.

DJ This film packet is too old to process.

DL This control packet appears to have been placed in a badge holder, indicating possible misuse. May we remind you that the value of the control films is lost if used for personnel monitoring or other radiation measurement purposes.

DR This film appears to have been exposed from the rear of the badge.

DS Amounts shown in columns 8 & 9 have been permanently subtracted from cumulative totals at customer's request.

DT Amounts shown in columns 8 & 9 have been permanently added to cumulative totals at customer's request.

DU Amounts shown in columns 8 & 9 have been supplied by customer for period prior to inception of Landauer service and have been permanently added to cumulative totals.

DV Amounts shown in columns 8 & 9 are previous lifetime exposures supplied by customer and have been permanently added to cumulative totals.

DY Other comment - See attached note.

DZ Other comment - See attached note.

E Irregular exposure.

E-1 Due to the irregular exposure the effective energy cannot be properly determined and the dosage is estimated arbitrarily based on 60 to 150 PKV x-rays as probable source of exposure. If different energy, the value reported will not be the actual dosage.

E-2 Due to the irregular exposure the effective energy cannot be properly determined and the dosage is estimated arbitrarily based on gamma or x-ray over 400KeV as probable source of exposure. If different energy, the value reported will not be the actual dosage.

H Unused.

QC Dosimeter received and processed. Quality control has not authorized reporting of doses. A separate report containing the doses for this dosimeter will be forthcoming.

DOSIMETER TYPE USED (COLUMN 5)

A X, GAMMA, BETA, FAST NEUTRON (NEUTRAK II)
B X, GAMMA, BETA, FAST NEUTRON (NEUTRAK 144)
C X, GAMMA, BETA, FAST NEUTRON (NEUTRAK 144), THERMAL NEUTRON
D REACTOR TLD
E NEUTRAK I
F TLD (4 CHIPS), FAST NEUTRON
G X, GAMMA, BETA
H X, GAMMA, BETA, FAST NEUTRON (NTA FILM), THERMAL NEUTRON
I NEUTRAK-ER (TLD CARD & NEUTRAK 144)
J X, GAMMA, BETA, FAST NEUTRON (NEUTRAK II), THERMAL NEUTRON
K TLD (3 CHIPS)
L TLD (4 CHIPS)
M TLD (5 CHIPS)
N FAST NEUTRON (NEUTRAK 144)
*O TLD (1 CHIP), FAST NEUTRON (NEUTRAK II)
P X, GAMMA, BETA, FAST NEUTRON (NTA FILM)
Q DEXRAY*
R X, BETA, GAMMA, NEUTRON (NEUTRAKER FILM)
S X, BETA, GAMMA, NEUTRON (NEUTRAKER), (TLD, 3 CHIPS)
T TLD (2 CHIPS)
*U TLD (1 CHIP RING)
V ALBEDO ONLY (TLD CARD ONLY)
W ESCORT TLD
*X SPECIAL TLD
Y X, GAMMA, BETA, THERMAL NEUTRON
Z TLD 2 CHIPS, FAST NEUTRON (NEUTRAK 144)

OPTION CODE (WHEN USED)
1 ADDITIONAL BETA CALC. & COMBINATION HOLDER
2 ADDITIONAL BETA CALC
3 COMBINATION HOLDER
4 X CALCULATION FOR RING
* NOT SUBJECT TO NVLAP ACCREDITATION

RADIATION QUALITY (COLUMN 7)

The following codes are provided to identify the types and in some cases energies of radiation contributing to the dose equivalent.

P - x or gamma ray exposure. P may be followed by an H for high energy x or gamma rays (greater than 250 keV effective), M for moderate energies (between 100 and 250 keV effective) or L for low energies (less than 100 keV effective).

B - Beta particle exposure.

N - Neutron exposure. N may be followed by an F for fast and intermediate energy neutrons or a T for thermal neutrons.

PB- Combined exposure due to both x or gamma rays and beta particles. The beta particle dose will be printed as a second line in the shallow dose column and coded as B, indicating that the second line is the beta dose component of the combined shallow dose.

PN- Combined exposure due to x or gamma rays and neutrons. The neutron dose will be printed as a second line in the deep dose column. This line will be coded as NF or NT, indicating that the second line is the dose due to fast and intermediate energy neutrons or thermal neutrons, respectively.

ADJUSTMENTS (COLUMN 16)

Adjustments made to cumulative totals with this or previous report at customer request.

A - Additions
B - Subtractions
C - Additions & Subtractions
D - Dosage data supplied by customer for period prior to inception of Landauer service.
E - Dosage data supplied by customer for period prior to inception of Landauer service; additional changes have also been made.
F - Previous lifetime exposure supplied by customer.
G - Previous lifetime exposure supplied by customer; additional changes have also been made.

UNUSED PERMISSIBLE ACCUMULATED DOSE (COLUMN 17)

Unless birth date and lifetime exposure records are supplied by the customer, no values are reported in column 17. If this data is supplied, the difference between the participant's age (in years) and 18 (if age greater than 18) is multiplied by 5000. From this, we subtract the value shown in column 15. The result is that value given in column 17: [5000 (Age-18)-column 14]. The value in column 17 is computed monthly. Permissible values are based on January 8, 1957, recommendations of the National Committee on Radiation Protection and Measurements. These values are given for total body exposures only.

INCEPTION DATE OF PERMANENT TOTAL (COLUMN 21)

Available to client modification to meet specific administrative requirements and may not reflect actual beginning date of accumulated totals.

LANDAUER DOSIMETRY SERVICES ARE TESTED BY PRINCIPAL TESTING ORGANIZATIONS AGAINST CURRENT CONSENSUS INDUSTRY STANDARDS.

1. ABOUT TH ORT

This repor he deep and shalk for each participant based cn the to which the badge or dosimeter premise is that the radiation which is closely related in both quality a radiation which exposed that par which the dosimeter was worn.

2. USE OF CONTROL DOSIMETER

A control dosimeter is included wi dosimeters as a means to determ received during transit, and shou radiation-free area during the wear dosimeter reading is subtracted f reading of each participant. Failure dosimeter with your return shipm will not allow us to assess transit e and such transit doses will be ref cipant dose.

3. MINIMUM DOSE EQUIVALENT REP

Dose equivalents for the current m low the minimum measurable quant "M". The minimum measurable qu the dosimeter type and quality of ra Film and TLD dosimeters have a value of 10mrem for x and for energetic beta particles have a minimum reporting moderate energy neutron d reporting dose of 20mrem. Film dos neutrons have a minimum reporting c

4. CUMULATIVE TOTAL DATA

Cumulative totals equal the sum dosimeters returned for processing date. Minimal exposures are added quarters are selected to most near and state recording requirements date and length of monitoring periods

5. ADJUSTMENTS TO CUMULATIVE D

To aid in proper presentation of cords required by the NRC and bodies, amendments to the cumulati been made increasing or decreasi those originally reported. Such ame at the request of an authorized re client and are only to reflect s demonstrating that the dosimeter occurred in such a manner as to understate the true dosage to the (Refer to adjustment column.) Ad exposure prior to commencement o ular dosimeter assignment reported flected in the cumulative totals

6. DEEP AND SHALLOW DOS

The deep dose is the dos tions at a depth of 1cm (Considered are the effects of build of radiation in the body as estimate diameter sphere of tissue equivalen by the International Commission c and Measurements. The shallow dos dose equivalent from all radiations 0.007cm depth (7mg/cm²) In sch deep dose, the contributions to the e alent from radiation scattered within sidered. The deep dose should be alent to the whole body dose and th equivalent to the dose to the skin

Dose equivalents arising from e gamma rays will have a deep and ported. Depending on the energy o rays, the deep and shallow values r equal. For neutron exposures, the ported for the deep and shallow do exposures are only reported as a s alent.

2068825498 10-11-93 12:43PM P003 #34

Golder Associates Inc.

AIR MONITORING DATA SHEET

Date 1-10-93 Sheet 1 of ____

Job Name LAIDLAW Job Number 923-6114

Location Bridgeton, Mo

Time In ____ Time Out ____ Weather ____ Temp. ____ Wind D. ____ V ____

Instrument Type ____ Serial No. ____

Calibration Gas and Concentration ____ Instrument Reading ____ Span/Gain/RF Setting ____

* If more than one instrument is used, document calibration procedures and results for each additional instrument in recommendations section below and indicate the instrument used (eg. OVA, 361, OVM, etc.) for each observation.

Time	Station	Instr.*	Reading	Procedure/Observations/Comments
			Atmospheric 367" H_2O	
Sample	Port F1 -			12" ID
	Pressures	Inches	of H_2O	
	0.50		7	
	0.50		6	
	0.52		5	
	0.50		4	
	0.50		3	
H_2S	14 ppm			
1400 Local	Field Blank			3-L Tedlar bag filled to ~1.5 L
210 1410	F1			SAMPLE COLLECTED FROM FLARE FEED MAINLINE
1215 1415	F2			"
-23 1423	F3			"
TEMP	85.5 °F / 86.5 °F			
RH	56.9 %			
SAMPLE	PORT FS			8" ID SIDE FLARE LINE 9.5" OD
	PRESSURE	INCHES OT		
	- 0.06	6		
	VARIABLE	5		
'ST LOCAL	- 0.07	7.25		
300 1500	FS-1			SAMPLE COLLECTED FROM SIDE BURNER LINE

Recommendations

305 1505	FS-2		
1505 1510	FS-3		
1515	H_2S	16 ppm	MSA 361
TEMP	TEMP	67.5 °F / 71.0 / 70.2	TSI PRESSURE -.11 inches water
	RH	95.5 %	

Printed Name ____ Signature ____

Golder Associates Inc.

AIR MONITORING DATA SHEET

Date 3-11-93 Sheet 1 of 1

Job Name Bridgeton Job Number 923-6114.002

Location Bridgeton, Mo, Hole Flare

Time In ______ Time Out ______ Weather Clear Temp. ______ Wind D. NW V 15 mph

Instrument Type MSA 361 Serial No. ______

Calibration Gas and Concentration H_2S - 10 & 40 ppm Instrument Reading 10 (36) Span/Gain/RF Setting ______

If more than one instrument is used, document calibration procedures and results for each additional instrument in recommendations section below and indicate the instrument used (eg. OVA, 361, OVM, etc.) for each observation.

Time	Station	Instr.*	Reading	Procedure/Observations/Comments
Velocity	Traverses	8" ID	Duct,	Midpoint 13 ft downstream and 13 ft upstream from nearest
Distance	~~at~~ 0.36		at 6½ out	disturbance
	0.32		at 4" out	
	0.32		at 8" out	
H_2S	18 ppm			
O_2	~~4.2 ppm~~	4.2 %		
11:50	361	Tox Zero	10 ppm reads 10 ppm	40 ppm read 36

Recommendations

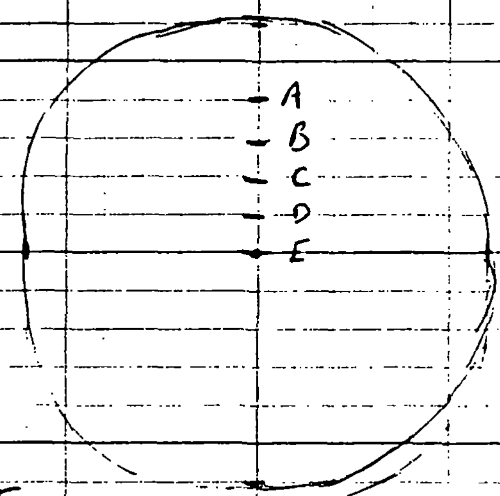
Printed Name ______ Signature ______

Golder Associates

SUBJECT		
Job No.	Made by	Date
Ref.	Checked	Sheet of
	Reviewed	

Sample Port F1 Duct 12"

Point	Pressure	Amount Pitot out	Distance into Duct
A	0.50	7	2"
B	0.50	6	3"
C	0.52	5	4"
D	0.50	4	5"
E	0.50	3	6"



Atmospheric Pressure 367" H_2O 30.25

Relative Humidity 95%

Temperature 70°F Correction Factor .989

Density of Air 0.075

Air Velocity 900 ft/m.

Golder Associates Inc. 02

AIR MONITORING DATA SHEET

Date 3-10-93 Sheet 1 of 1

Job Name Laidlaw Bridgeton Job Number 923-6114.002

Location Bridgeton - Econolodge Rm 105, 4575 N Lindbergh, Bridgeton Mo 6

Time In ______ Time Out ______ Weather ______ Temp. ______ Wind D. ______ V ______

Instrument Type ______ Serial No. ______

Calibration Gas and Concentration ______ Instrument Reading ______ Span/Gain/RF Setting ______

** If more than one instrument is used, document calibration procedures and results for each additional instrument in recommendations section below and indicate the instrument used (eg. OVA, 361, OVM, etc.) for each observation.*

Time	Station	Instr.*	Reading	Procedure/Observations/Comments
In 9:45 PST	3-9-93	8704-61	40	Room Back ground - 4 hrs
1:45 PST	3-10-93			Rotameter 1 l/m at bottom of ball
In 6:50 PST	3-10-93	8704-61		Chevy S-10 ~~license~~ # 168032
Finish 2:30 PST	3-10-93		31 counts	Tims Truck; weather partly cloudy, Windy
In 7:10 PST	3-10-93	8908-381		RCX 321 - Number on side is
Finish 2:22 PST			21 counts	320-A, with a black 40.
				Rotameter 1 l/m bottom of ball.
				winds 10-15 mph
Start 3:00 pm PST		8704-61		Mechanics Room, 1st Desk, Across to the right.
Finish 5:10 pm PST			315 counts	6.3
				.0058 WL
Start 3:03 pm PST		8908-381		Break Room
Finish 5:13 pm PST			230	7.2 cf
				.0037 WL
17 mph	30.215 BP			
Start 6:08 pm PST	3-11-93	8908-381	CF 7.2	Located in Scale house
Finish 2:30 pm PST			6	
Start 6:35 am PST	3-11-93	8704-61	CF 6.3	HF-311 (2nd rex)
Finish 9:30 am PST	3-11-93		2 counts	

Restart 9:30 am PST 3-11-93
Accidental Turnoff.

Recommendations

Finish 2:46 pm PST 12 counts

Joseph Ellerhoff

Printed Name ______ Signature ______

Golder Associates

AIR [illegible]TORING DATA SHEET

Date 3-11-93 Sheet 1 of ____

Job Name Bridgeton Landfill Job Number 923-6114.002

Location West Lake Mechanics Shop

Time In ____ Time Out ____ Weather High overcast Temp. ____ Wind D. ____ V ____

Instrument Type TNWL 02 WL Meter Serial No. ____

Calibration Gas and Concentration ____ Instrument Reading ____ Span/Gain/RF Setting ____

* *If more than one instrument is used, document calibration procedures and results for each additional instrument in recommendations section below and indicate the instrument used (eg. OVA, 361, OVM, etc.) for each observation.*

Time	Station	Instr.*	Reading	Procedure/Observations/Comments
West Lake Mechanics Shop				
	Work bench	8704-061		CF 6.3
3-11-93	Start time		3:24 PM PST	
3-12-93	Finish time		5:30 AM PST	76
Westlake Building	Office	8908-381		CF 7.2
3-11-93	Start time		3:25 pm PST	
3-12-93	Finish		5:32 Am PST	71
Joe Duraka's office				
3-12-93		8908-381		CF 7.2
start time 5:55 AM PST				220
Finish 3-12-93 12:53 PM PST				0.004 WL
D-8 by Demolition dump.				
		8704-061		CF 6.3
Start time 6:55 Am PST				
Finish 1:35 pm PST			4	

Recommendations

Joe Eckhoff
Printed Name

Signature

Golder Associates

SUBJECT WL Meter Field Calibration

Job No.
Ref.
Made by
Checked
Reviewed
Date
Sheet of

Response Rentals Serial No. 8704-061 C.F 6.3 CPH/mWL

Field Calibration

First Six Tests using the check source supplied by Response Rentals for this instrument. 30 minute periods

Counts Counts/30min

2291 (76.36)

$n = 6$

2383 (79.4)

2318 (77.2) $\bar{x}$ 2319.8 (77.31)

2319 (77.3) σ_{n-1} = 33.99 (1.12) $\mathrm{var}_{\sigma_{n-1}}$ 1155.3 (1.26)

2319 (77.3) σ_n = 31.029 (1.02) var_{σ_n} = 962.8 (1.05)

2289 (76.3) var_{σ_n} =

16302

Golder Associates

SUBJECT WL Meter Field Calibration
Job No. 923-6114.002
Ref.
Made by
Checked
Reviewed
Date 3-3-93
Sheet of

Out Site Rentals Serial No. 8908-381 Cal Fac 7.2 cpm/mw

Field Calibration

First Six Test Runs using the Check Source (Response Rentals)
30 minute time period

Counts	(counts/sec min)		
1862	(62.07)		$N = 6$
1844	(61.5)		$\bar{x} = 1830\ (60.99)$
1832	(61.1)	Sample std	$\sigma_{n-1} = 33.29\ (1.124)$ $Var_{\sigma_{n-1}} = 1088\ (1.26)$
1858	(61.9)		$\sigma_n = 30.39\ (1.026)$ $Var_{\sigma_n} = 924\ (1.05)$
1774	(59.1)		
1810	(60.3)		

Golder Associates Inc.

AIR MONITORING DATA SHEET

Date 3-8-93 Sheet ____ of ____

Job Name Laidlaw Job Number 923-6119.

Location Office

Time In ____ Time Out ____ Weather ____ Temp. ____ Wind D. ____ V ____

Instrument Type ____ Serial No. ____

Calibration Gas and Concentration ____ Instrument Reading ____ Span/Gain/RF Setting ____

* *If more than one instrument is used, document calibration procedures and results for each additional instrument in recommendations section below and indicate the instrument used (eg. OVA, 361, OVM, etc.) for each observation.*

Time	Station	Instr.*	Reading	Procedure/Observations/Comments
				CALIBRATION ROTOMETER
3/8/93	Bubbler inlet	1L/m	6.1 sec	8704-001
		1L/m	6.0 sec	bottom of ball at 1.0 L/m
		1L/m	6.0 sec	
		1L/m	6.1 sec	
		1L/m	6.0 sec	

Recommendations

____

Printed Name ____ Signature ____

Golder Associates

SUBJECT LAIDLAW WL Calculations

Job No. 923-6114.020

Ref.

Made by JR

Checked

Reviewed

Date

Sheet of

Instrument 8704-61 CF = 6.3 CPH/mWL

Instrument 8908-381 CF = 7.2 CPH/mWL

C-10

$\frac{31}{(7.67-.5)*6.3} = \frac{31}{(7.17)*6.3 = 45.17}$ .686 mWL

.00068 WL

Rex

$\frac{21}{(7.36-.5)*7.2} = \frac{21}{49.39}$ = .425 = .000425

Mechanics

$\frac{315}{(14.17-.5)*6.3} = \frac{315}{86.12}$ = 3.66 mWL = .00366 WL

Employees

$\frac{230}{(14.15-.5)*7.2} = \frac{230}{98.28}$ = 2.34 mWL = .0023

Scale

$\frac{6}{(8.2-.5)*7.2} = \frac{6}{55.44}$ = .11 mWL = .00011 WL

Rex

$\frac{2}{(2.92-.5)*6.3} = \frac{2}{15.25}$ = .13 mWL = .00013 WL

$\frac{12}{(5.27-.5)*6.3} = \frac{12}{30.05}$ = .40 mWL .0004 WL

Westlake Mech

$\frac{76}{(14.13-.5)*6.3} = \frac{76}{85.86}$ = .88 mWL = .00088 WL

CONTAMINATION SURVEY DATA SHEET

Golder Associates

Job Name Bridgeton Landfill Job Number 923-6114.002

Location Offices, Site Equipment

Time In ____ Time Out ____ Weather ____ Temp. ____

Wind D. ____ Velocity ____ Instrument Type ESP-1, Alpha Probe Serial No. 407785 Alpha

Calibration ____ Dead time 1.2 x 10^-5 HV 1.25 x 10^3

Location (Coordinates/ Description)	Direct Probe Measurment ~~Gamma~~ Alpha c/m	µR/h at 1m	Alpha c/m (Removable Alpha)	~~d/m/100cm²~~	~~Removable Contaminants Beta-Gamma c/m~~	~~d/m/1--cm²~~
Locker Room Locker 22	~~8~~		4			
Joe's office, ~~under~~	~~7~~		5	Floor left corner of desk		
Secretaries office computer desk	~~No Counts~~		No Counts			
Lunch Room, table	~~No Counts~~		No Counts			
Mechanics office, desk	~~No Counts~~		No Counts		Background	
C-10 Chevy Pickup JOES	~~No Counts~~		No Counts			
Office Bldg SE corner	~~4 pgs 1.56+01~~		4 pgs 1.56+01			
Laidlaw Fuel Truck Truck, Top of fender (Front Left) #144427			No Counts			
Laidlaw waste oil truck, Top of Fender (Left Front)			No Counts			
Laidlaw Mechanics Truck, Top fender (Left Front)			No Counts			
Laidlaw Case Mini-Front end Loader, Left Front Frame Member			1 count 1.10+01			
Rex Interior: Top of instrument panel						
Rex Exterior Door			1 count 1.3+01			
Cat 963: Adjacent to lift controls			2 counts 1.24+01			
Westlake Mechanics Shop Interior: Door of metal Locker in office			No Counts			
DynaPac CA15: Top of Instrument Panel			No Counts			
Guard Shack Exterior: SW Corner			2 pops 1.39+01			

Margin notes: 10 AM PST; 1 *; 10:50 am PST; 1:05 pm PST; 2 pm PST Finish

Procedure/Observations/Comments Whatman 50 - 5.5 cm Paper

Wipe of Soils by stake 15 - 5 pops - 1.31+01

X Joe Eckhoff
Printed Name

X Joe Eckhoff
Signature

Golder Associates

CONTAMINATION SURVEY DATA SHEET

5 sec control time
Temp 28°F
Rel. Hum 50%
Barometer 30.255

3-11-93

Winds 17 mph NW Chill Fact 4

Job Name Bridgeton Landfill Job Number 923-6114.002

Location Main office Building, Employee Scans

Time In ______ Time Out ______ Weather ______ Temp. ______

Wind D. ______ Velocity ______ Instrument Type ESP-1, HP260 Serial No. ______

Calibration ______ Dead time unknown

	Location (Coordinates/ Description)	Direct Probe Measurment Gamma c/m	µR/h at 1m	Alpha c/__m	d/m/100cm²	~~Removable Contaminants~~ Beta-Gamma c/m	c/m ~~d/m/1 cm²~~
0730	BACKGROUND - ROOM					90 peak	40 Avg
	SHAWN WILSON					52	30s
	KELVIN HENDERSON					77	
	GARLAND ZIMMERMAN					78	
	JOHN COUNTS					98	
L olan / F ...	RICHARD RESSEL					84	
	CARL SCHWERDTNER (HAS BEEN WORKING: HEAVY EQUIP MECHANIC)					84	
	GLENN O'BRYAN					52	
	JOE DURAKO					92	
1630							
	CARL SCHWERDTNER					86	35s
	KELVIN HENDERSON					89	45
	RICHARD RESSEL					75	50s
LAIDLAW PERSONNEL	JOHN COUNTS					72	40s
	SHAWN WILSON					79	30s
	GARLAND ZIMMERMAN					80	40s
	GLENN O'BRYAN					94	45
	Background metal grass 35 cm from BST ...					66	

Procedure/Observations/Comments

CHRISTOPHER RIFE (GOLDER TECHNICIAN) 0730 88 45
1700 90 30s

X CHRISTOPHER RIFE
Printed Name

X [signature]
Signature

Typ Back 50-100

Golder Associates

CONTAMINATION SURVEY DATA SHEET

Job Name: Bridgeton Landfill Job Number: 923-6114.002

Location: Employee Scans - Break Room

Time In: ______ Time Out: ______ Weather: ______ Temp.: ______

Wind D.: ______ Velocity: ______ Instrument Type: ESP-1, HP260 Serial No.: ______

Calibration: ______ Dead time 9.98x10^{-7}

Location (Coordinates/ Description)	Direct Probe Measurment Gamma c/m	µR/h at 1m	Alpha c/__m	d/m/100cm²	~~Removable Contaminants~~ Beta-Gamma c/m	cm ~~d/m/1 cm²~~
1:35 PST pm Background Room				81	Peak	42 Ave
Eric Stuber					93	45
Robert Brusewitz					98	40
1:15 PST Randy Meibaum ✓					94	35
3:30 PST Richard Ferris ✓					80	32
Vernon England ✓					90	40
Out		HV 900 Dead 6.35x10^{-5}				
1:30 PST Randy Meibaum					~~28~~ 80	~~80~~ 28
2:35 PST Richard Ferris					71	45
Vernon England					~~38~~ 60	~~60~~ 38
Tim Johnson					102	38
1:10 pm PST Eric Stuber					92	42
Rob Brusewitz					72	43

Procedure/Observations/Comments: Note: Be sure to get Tim

X Joe Eckhoff JOE ECKHOFF
Printed Name

X Joe Eckhoff
Signature

Golder Associates

SURFACE MEASUREMENTS DATA SHEET

Date 3-12-93 Sheet 1 of ____

Job Name ____________________ Job Number 923-6114.002

Location On-site as identified

Time In ________ Time Out ________ Weather Clear, 15 mph wind Temp. 28 °F

Wind D. ________ Velocity ________ Instrument Type ESP-1, Gamma Sc Serial No. ________

Calibration ________ Instrument Reading ________ Voltage 900 EV Dead time 1×10⁻⁵

Scan Rate 10–20cm/sec. ________

Grid Line/Coordinates ________

	SCINT	GM	
Instruments			
Probes			

Location	Scintillation @ 5-1/2		~~GM @ 1 cm~~ Scintillation at 18"		Remarks
	~~cpm x 1000~~		c/__m		
	1 Meter	Contact ~~(10cm)~~ 5½"	Open	Closed	
Background					
West Lake Mechanics SE		min 1500 max 2000	*		SE corner adjacent to concrete pad
West Lake		1200 1400			SW corner adj. to pad
West Lake		1100 1300			NW
West Lake		1000 1200			NE
Blue & White Bldg		1500 1900			SE corner
		1100 1800			SW corner
		1500 1800			NW corner
		1700 2000			NE corner
Duplicate					

Duplicate measurements will be performed as follows:
<10 measurements = 1 duplicate
> 10 one duplicate for every 10 measurements + duplicate for fraction over 10

Remarks ____________________

Surveyor(s) X Joe Elkhoff X ________
X ________ X ________

* ~~gds~~ 0.00+03

Golder Associates

SURFACE MEASUREMENTS DATA SHEET

Date 3-17-93 Sheet 2 of 3

Job Name ______ Job Number ______

Location ______

Time In ______ Time Out ______ Weather ______ Temp. ______

Wind D. ______ Velocity ______ Instrument Type ______ Serial No. ______

Calibration ______ Instrument Reading ______

Scan Rate 10–20cm/sec. ______

Grid Line/Coordinates ______

	SCINT	GM	
Instruments			
Probes			

Location	Scintillation 5½		GM @ 1 cm		Remarks
	~~cpm x 1000~~ cpm		c/__ m		
	1 Meter	Contact ~~(10cm)~~ 5½"	Open	Closed	
Background					
Area 2-A		Ave 2300 Max 2800			A = 1st stake from [illegible] A
B		2100 2300			
C		2500 2800			
D		2400 2700			
E		2300 2500			
F-26		2000 2500			NW CORNER (peak 4300)
					~8900 c/m 250' E of NW corner, along fenceline
G-27					25'S (~300' peak 20,000)
H-28		1800 2000			~600' FROM NW CORNER
~~Duplicate~~ I-29		2100 2400			~850' FROM NW CORNER.
					N of E BERM, ~15' S of Fence line

Duplicate measurements will be performed as follows:
<10 measurements = 1 duplicate
> 10 one duplicate for every 10 measurements + duplicate for fraction over 10

Remarks ______

Surveyor(s) X Joe Ekhoff X ______
X ______ X ______

SURFACE MEASUREMENTS DATA SHEET

Golder Associates

Date 3/12/93 Sheet 3 of 3

Job Name LAIDLAW/BRIDGETON RA/MO Job Number 923-6114

Location BRIDGETON SANITARY LANDFILL — LEACHATE LAGOON

Time In 1015 Time Out ______ Weather Pt CLOUDY Temp. 25°F

Wind D. SOUTHEASTERLY Velocity 5-10 mph Instrument Type ESP-1 Serial No. ______

Calibration ______ Instrument Reading ______

Scan Rate 10–20cm/sec. ______

Grid Line/Coordinates ______

	SCINT	GM	
Instruments			
Probes			

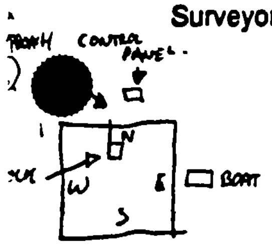
Location	Scintillation		GM @ 1 cm		Remarks
	cpm ~~x 1000~~ CPM		c/__m		
	1 Meter	~~Contact (10cm)~~ 5.5"	Open	Closed	
Background		Avg Peak			
CONTROL PANEL		1800 1900			
DOCK APPROACH		1800 2200			
DOCK	2nd PASS 1st PASS	700 900 500 600			
N BANK		1900 2200			
S BANK		2000 2200			
E BANK		1900 (5) 2200			
W BANK		1900 2200			
BOAT		1900 2200			
~~Duplicate~~ BACKGROUND		5.5" 2300	18" 2300	GAMMA SCINTILLATION	
		50	MAX 90	HP260 BETA/GAMMA	
		0.02		ALPHA SCINTILLATION	

HV 900
1.2×10⁻⁵ sec
HV 900
6.3×10⁻⁵ sec
23×10³
1.2×10⁻⁵

Duplicate measurements will be performed as follows:
<10 measurements = 1 duplicate
> 10 one duplicate for every 10 measurements + duplicate for fraction over 10

Remarks ______

Surveyor(s) X [signature] X ______
X ______ X ______



SURFACE MEASUREMENTS DATA SHEET

Golder Associates

i:ltage

(32 E 12

Date 3-11-98 Sheet 1 of ____

Job Name Bridgeton Landfill Job Number 923-6114.002

Location ~~Grn~~ On-site as Identified

Time In ____ Time Out ____ Weather Clear, BP 30.21 S Temp. 28°F

Wind D. NW Velocity 17 mph Instrument Type SBP-1, Gamma Cell Serial No. HS 0010 -ESPI PR097828

Calibration ____ Instrument Reading ____

Scan Rate 10–20cm/sec. ____

Grid Line/Coordinates ____

	SCINT	GM	
Instruments			
Probes			

Location	Scintillation cpm x 1000		Scintillation ~~GM @ 1 cm~~ ~~18~~ 5½" cps ~~c-1m~~		Remarks
	1 Meter	Contact (10cm)	~~Open~~	~~Closed~~ cpm	
Background			Ave Max	Ave Max	
Point # 1			62 76	3720 4560	
well # 2			61 72	3660 4320	
Well 1			63 81	3780 4860	
PT 2			68 71	4080 4260	
PT 9			64 76	3840 4560	
PT 7			58 79	3480 4740	
PT 8			58 71	3480 4260	
Well 3			63 99	3780 5940	
Well 4			60 74	3600 4400	
Duplicate					
Background Motel	18"	5,500 c/m	/ Dead time unknown		

Duplicate measurements will be performed as follows:

<10 measurements = 1 duplicate

> 10 one duplicate for every 10 measurements + duplicate for fraction over 10

Remarks ____

Surveyor(s) X Joe Ekhoff X ____

X ____ X ____

8,000-10,000 c/m

SURFACE MEASUREMENTS DATA SHEET

Golder Associates

Date 3/11/93 Sheet 2 of ____

Job Name BRIGHTON LANDFILL Job Number 923-6114.002

Location ONSITE

Time In ____ Time Out ____ Weather CLEAR, BP 30.215 Temp. 28°F

Wind D. NW Velocity 17MPH Instrument Type ESP-1, GAMMA Serial No. MS001C-ESP PRO 09878

Calibration ____ Instrument Reading ____

Scan Rate 10-20cm/sec. ____

Grid Line/Coordinates ____

1/2 TRACE 9.02E12

	SCINT	GM	
Instruments			
Probes			

Location	Scintillation cpm x 1000		GM @ 1 cm ~~c/__ m~~				Remarks
	1 Meter	Contact (10cm)	cps ~~Open~~		~~Closed~~ cpm		
Background			Avg	Peak	Ave	Peak	
Well 5			66	94	3960	5640	
HEADER AT MAIN FLARE			60	67	3600	4020	
CONTROL PANEL AT MAIN FLARE			55	69	3300	4140	
WELL 8			63	92	3780	5520	
WELL 9			58	70	3480	4200	
WELL 10			57	83	3420	4980	
PT3			63	77	3780	4620	
PT4			61	72	3660	4320	
PT5			65	73	3900	4380	
Duplicate							

Duplicate measurements will be performed as follows:
<10 measurements = 1 duplicate
> 10 one duplicate for every 10 measurements + duplicate for fraction over 10

Remarks ____

Surveyor(s) X Joe Elkoff X ____

X ____ X ____

SURFACE MEASUREMENTS DATA SHEET

Golder Associates

Date 3/11/93 Sheet 3 of ____

Job Name BRIDGETON LANDFILL Job Number 923-6114.002

Location ONSITE

Time In ____ Time Out ____ Weather CLEAR BP 30.21 Temp. 30°F

Wind D. NW Velocity 17 MPH Instrument Type ESP-1, GAMMA Serial No. MS0010-ESP1 PR097878

Calibration ____ Instrument Reading ____

Scan Rate 10–20cm/sec. ____

Grid Line/Coordinates ____

1 TPLE 9.02 E+2

	SCINT	GM	
Instruments			
Probes			

Location	Scintillation cpm x 1000		GM @ 1 cm c/__m 4s				Remarks
			~~c/m~~ c/m				
	1 Meter	Contact (10cm)	~~Open~~ Avg	Peak	~~Closed~~ Avg	Peak	
Background							
PT10			66	80	3960	4800	
PT11			59	69	3540	4140	
PT13			65	117	3900	7020	CONSISTENT 70, RANGE 50-117
PT14			70	95	4200	5700	
PT6			62	128	3720	7680	
PT12			68	144	4080	8640	
PT18			70	90	4200	5400	
PT20			78 (1)	120 (2)	7200 (3)	9000 (4)	
PT17			200 (5)	~~217~~ 283 (6)	9000 (4)	10,100 (6)	
Duplicate							

Duplicate measurements will be performed as follows:
<10 measurements = 1 duplicate
> 10 one duplicate for every 10 measurements + duplicate for fraction over 10

Remarks (1) 4680 cpm (2) 7200 cpm (3) Resurveyed (4) Resurveyed (5) 12000 cpm (6) 17,000 cpm

Surveyor(s) X Joe Ekhoff
X

X
X

SURFACE MEASUREMENTS DATA SHEET

Golder Associates

Date 3-11 Sheet 3/ of 4

Job Name ' Job Number

Location Probe 5/12

Time In Time Out Weather Temp.

Wind D. Velocity Instrument Type Serial No.

Calibration Instrument Reading

Scan Rate 10–20cm/sec.

Grid Line/Coordinates

	SCINT	GM	
Instruments			
Probes			

Location	Scintillation		GM @ 1 cm				Remarks
	cpm x 1000		c/s		c/__m c/m		
	1 Meter	Contact (10cm)	Avg Open	Peak	Avg ~~Closed~~	Pk	
Background							
PT15			145 ~~168~~ CR	217	10,000 (1)	50,000 (1)	Peak 1000 c/s in line w/PT17 20's
✓							570 ~ 2M in line w/PT17
PT16			720	1040	41,000 (1)	57,000 (1) 47 CR	Peak 1022 50' between PT16 & PT15
PT19			55	71	2,600 (1) ~~3,200~~	3,300 ~~3400~~ CR	
NW CORNER AREA 1			67 (4020)	73 (4380)			
GATE			36 (2160)	47 (2820)			
Duplicate							Note: Hit Ø
Note: 0.2 mR/hr	associated	with	50,000 c/m above background.				
							has not been taken.

Duplicate measurements will be performed as follows:
<10 measurements = 1 duplicate
> 10 one duplicate for every 10 measurements + duplicate for fraction over 10

Remarks (1) Resurveyed

Surveyor(s) X Joe Eckhoff X

X X

Go get a good background and stay away from man-made structures 100 ft.

change in status.

APPENDIX C

PARAMETERS USED IN SCREEN EXPOSURE MODEL FOR ESTIMATING RADON GAS CONCENTRATIONS FROM FLARE EMISSIONS

APPENDIX C

PARAMETERS USED IN SCREEN EXPOSURE MODEL FOR ESTIMATING RADON GAS CONCENTRATIONS FROM FLARE EMISSIONS

Main Flare

Assumptions:

Operating at design capacity of 2,500 cfm
60% methane in LFG at 255, 300 cal/ft^3
180 pCi/liter Rn-222 in LFG = 5,094 pCi/ft^3
2,500 cfm x min/60 sec x 5,094 pCi/ft^3 = 212,250 pCi/sec
= 0.212E-03 mCi/sec
2,500 cfm x 0.6 x 255,300 cal/ft^3 x min/60 sec = 6,382,500 cal/sec
Stack height 40 feet = 12.2 meters

12-Inch Auxiliary Flare

Assumptions:

Operating at design capacity of 1,300 cfm
60% methane in LFG at 255,300 cal/ft^3
180 pCi/liter Rn-222 in LFG = 5,094 pCi/ft^3
1,300 cfm x min/60 sec x 5,094 pCi/ft^3 = 110,370 pCi/sec
= 0.110E-03 mCi/sec
1,300 cfm x 0.6 x 255,300 cal/ft^3 x min/60 sec = 3,318,900 cal/sec
Stack height 10 feet = 3.05 meters
Terrain height of 4 m above stack base

8-Inch Utility Plane

Assumptions:

Operating at design capcity of 2,000 cfm
60% methane in LFG at 255,300 cal/ft^3
180 pCi/liter Rn-222 in LFG
180 pCi/liter x 28.3 liter/ft^3 = 169,800 pCi/sec
= 0.17E-03 mCi/sec
2,000 cfm x 0.6 x 255,300 cal/ft^3 x min/60 sec = 5,106,000 cal/sec
Stack height = 20 ft x 1 m/3.28 ft = 6 meters

Complex terrain option:

46-meter cliff, 250 meters from flare

08-25-93
02:00:13

*** SCREEN-1.1 MODEL RUN ***
*** VERSION DATED 88300 ***

[illegible]IDGETON LANDFILL MAIN FLARE

SIMPLE TERRAIN INPUTS:

SOURCE TYPE	=	FLARE
EMISSION RATE (mCi/S)	=	.2120E-03
FLARE STACK HEIGHT (M)	=	12.20
TOT HEAT RLS (CAL/S)	=	.6382E+07
RECEPTOR HEIGHT (M)	=	.00
IOPT (1=URB,2=RUR)	=	1
EFF RELEASE HEIGHT (M)	=	20.36
BUILDING HEIGHT (M)	=	.00
MIN HORIZ BLDG DIM (M)	=	.00
MAX HORIZ BLDG DIM (M)	=	.00

BUOY. FLUX = 105.81 M**4/S**3; MOM. FLUX = 64.52 M**4/S**2.

*** FULL METEOROLOGY ***

****
*** SCREEN AUTOMATED DISTANCES ***
****

*** TERRAIN HEIGHT OF 0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

DIST (M)	CONC (pCi/L)	STAB	U10M (M/S)	USTK (M/S)	MIX HT (M)	PLUME HT (M)	SIGMA Y (M)	SIGMA Z (M)	DWASH
10.	.0000	0	.0	.0	.0	.0	.0	.0	
100.	.7446E-04	4	20.0	23.9	5000.0	44.7	15.8	13.9	NO
200.	.8785E-03	4	20.0	23.9	5000.0	44.7	30.9	27.4	NO
300.	.8325E-03	4	20.0	23.9	5000.0	44.7	45.5	40.4	NO
400.	.7008E-03	4	15.0	17.9	4800.0	54.5	59.8	53.3	NO
500.	.6236E-03	4	10.0	11.9	3200.0	73.5	73.9	66.3	NO
600.	.5575E-03	4	8.0	9.6	2560.0	86.8	87.7	79.0	NO
700.	.4897E-03	4	8.0	9.6	2560.0	86.8	100.6	90.9	NO
800.	.4505E-03	4	5.0	6.0	1600.0	126.6	115.5	105.1	NO
900.	.4471E-03	5	2.0	2.5	5000.0	124.3	89.9	55.6	NO
1000.	.5048E-03	5	2.0	2.5	5000.0	124.3	97.6	58.7	NO
1100.	.5520E-03	5	2.0	2.5	5000.0	124.3	105.1	61.7	NO
1200.	.6046E-03	5	1.0	1.2	5000.0	151.3	114.8	68.5	NO
1300.	.6564E-03	5	1.0	1.2	5000.0	151.3	121.9	71.2	NO
1400.	.7010E-03	5	1.0	1.2	5000.0	151.3	128.8	73.8	NO
1500.	.7389E-03	5	1.0	1.2	5000.0	151.3	135.7	76.4	NO
1600.	.7705E-03	5	1.0	1.2	5000.0	151.3	142.4	78.9	NO
1700.	.7964E-03	5	1.0	1.2	5000.0	151.3	149.0	81.3	NO
1800.	.8172E-03	5	1.0	1.2	5000.0	151.3	155.5	83.7	NO
1900.	.8336E-03	5	1.0	1.2	5000.0	151.3	161.9	86.0	NO
2000.	.8461E-03	5	1.0	1.2	5000.0	151.3	168.2	88.3	NO
2100.	.8552E-03	5	1.0	1.2	5000.0	151.3	174.4	90.6	NO
2200.	.8614E-03	5	1.0	1.2	5000.0	151.3	180.4	92.8	NO
2300.	.8650E-03	5	1.0	1.2	5000.0	151.3	186.4	94.9	NO
2400.	.8665E-03	5	1.0	1.2	5000.0	151.3	192.2	97.0	NO
2500.	.8662E-03	5	1.0	1.2	5000.0	151.3	198.0	99.1	NO

```
MAXIMUM 1-HR CONCENTRATION AT OR BEYOND    10. M:
   233.   .9208E-03    4    20.0    23.9  5000.0    44.7     36.0     31.9     NO

 DWASH=   MEANS NO CALC MADE (CONC = 0.0)
 DWASH=NO MEANS NO BUILDING DOWNWASH USED
 DWASH=HS MEANS HUBER-SNYDER DOWNWASH USED
 DWASH=SS MEANS SCHULMAN-SCIRE DOWNWASH USED
 DWASH=NA MEANS DOWNWASH NOT APPLICABLE, X<3*LB

     ***************************************
     *** SUMMARY OF SCREEN MODEL RESULTS ***
     ***************************************

 CALCULATION           MAX CONC    DIST TO   TERRAIN
  PROCEDURE             (pCi/L)    MAX (M)    HT (M)
--------------      -----------    -------   -------
SIMPLE TERRAIN        .9208E-03       233.        0.

***************************************************
** REMEMBER TO INCLUDE BACKGROUND CONCENTRATIONS **
***************************************************
```

08-25-93
01:37:14

*** SCREEN-1.1 MODEL RUN ***
*** VERSION DATED 88300 ***

DGETON LANDFILL 12 INCH AUXILIARY FLARE

SIMPLE TERRAIN INPUTS:

SOURCE TYPE	=	FLARE
EMISSION RATE (mCi/S)	=	.1100E-03
FLARE STACK HEIGHT (M)	=	3.05
TOT HEAT RLS (CAL/S)	=	.3319E+07
RECEPTOR HEIGHT (M)	=	.00
IOPT (1=URB,2=RUR)	=	1
EFF RELEASE HEIGHT (M)	=	9.02
BUILDING HEIGHT (M)	=	.00
MIN HORIZ BLDG DIM (M)	=	.00
MAX HORIZ BLDG DIM (M)	=	.00

BUOY. FLUX = 55.03 M**4/S**3; MOM. FLUX = 33.56 M**4/S**2.

*** FULL METEOROLOGY ***

****
*** SCREEN AUTOMATED DISTANCES ***
****

*** TERRAIN HEIGHT OF 0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

DIST (M)	CONC (pCi/L)	STAB	U10M (M/S)	USTK (M/S)	MIX HT (M)	PLUME HT (M)	SIGMA Y (M)	SIGMA Z (M)	DWASH
10.	.0000	0	.0	.0	.0	.0	.0	.0	
100.	.8756E-03	4	20.0	20.0	5000.0	29.2	15.8	13.9	NO
200.	.1168E-02	4	20.0	20.0	5000.0	29.2	30.9	27.4	NO
300.	.8327E-03	4	10.0	10.0	3200.0	51.9	46.0	41.0	NO
400.	.6840E-03	4	8.0	8.0	2560.0	62.6	60.6	54.2	NO
500.	.5685E-03	4	8.0	8.0	2560.0	62.6	74.3	66.7	NO
600.	.4868E-03	4	5.0	5.0	1600.0	94.8	89.6	81.1	NO
700.	.5538E-03	5	2.0	2.0	5000.0	98.8	72.7	46.8	NO
800.	.6234E-03	5	2.0	2.0	5000.0	98.8	80.8	50.2	NO
900.	.6827E-03	5	1.0	1.0	5000.0	122.1	90.8	57.0	NO
1000.	.7495E-03	5	1.0	1.0	5000.0	122.1	98.4	60.0	NO
1100.	.8022E-03	5	1.0	1.0	5000.0	122.1	105.9	63.0	NO
1200.	.8421E-03	5	1.0	1.0	5000.0	122.1	113.2	65.8	NO
1300.	.8711E-03	5	1.0	1.0	5000.0	122.1	120.4	68.6	NO
1400.	.8908E-03	5	1.0	1.0	5000.0	122.1	127.5	71.3	NO
1500.	.9028E-03	5	1.0	1.0	5000.0	122.1	134.4	74.0	NO
1600.	.9088E-03	5	1.0	1.0	5000.0	122.1	141.2	76.6	NO
1700.	.9097E-03	5	1.0	1.0	5000.0	122.1	147.8	79.1	NO
1800.	.9068E-03	5	1.0	1.0	5000.0	122.1	154.4	81.5	NO
1900.	.9008E-03	5	1.0	1.0	5000.0	122.1	160.8	83.9	NO
2000.	.8924E-03	5	1.0	1.0	5000.0	122.1	167.1	86.3	NO
2100.	.8822E-03	5	1.0	1.0	5000.0	122.1	173.3	88.6	NO
2200.	.8706E-03	5	1.0	1.0	5000.0	122.1	179.4	90.8	NO
2300.	.8580E-03	5	1.0	1.0	5000.0	122.1	185.4	93.0	NO
2400.	.8447E-03	5	1.0	1.0	5000.0	122.1	191.3	95.2	NO
2500.	.8309E-03	5	1.0	1.0	5000.0	122.1	197.1	97.3	NO

```
MAXIMUM 1-HR CONCENTRATION AT OR BEYOND    10. M:
   150.    .1329E-02    4    20.0    20.0  5000.0      29.2      23.6      20.8      NO
```

DWASH=   MEANS NO CALC MADE (CONC = 0.0)
DWASH=NO MEANS NO BUILDING DOWNWASH USED
DWASH=HS MEANS HUBER-SNYDER DOWNWASH USED
DWASH=SS MEANS SCHULMAN-SCIRE DOWNWASH USED
DWASH=NA MEANS DOWNWASH NOT APPLICABLE, X<3*LB

****
*** SUMMARY OF SCREEN MODEL RESULTS ***
****

CALCULATION PROCEDURE	MAX CONC (pCi/L)	DIST TO MAX (M)	TERRAIN HT (M)
SIMPLE TERRAIN	.1329E-02	150.	0.

****
** REMEMBER TO INCLUDE BACKGROUND CONCENTRATIONS **
****

08-25-93
01:48:55

*** SCREEN-1.1 MODEL RUN ***
*** VERSION DATED 88300 ***

BRIDGETON LANDFILL 12 INCH AUXILIARY FLARE, ELEVATED TERRAIN

SIMPLE TERRAIN INPUTS:

```
   SOURCE TYPE              =    FLARE
   EMISSION RATE (mCi/S)    =    .1100E-03
   FLARE STACK HEIGHT (M)   =     3.05
   TOT HEAT RLS (CAL/S)     =    .3319E+07
   RECEPTOR HEIGHT (M)      =      .00
   IOPT (1=URB,2=RUR)       =     1
   EFF RELEASE HEIGHT (M)   =     9.02
   BUILDING HEIGHT (M)      =      .00
   MIN HORIZ BLDG DIM (M)   =      .00
   MAX HORIZ BLDG DIM (M)   =      .00
```

BUOY. FLUX = 55.03 M**4/S**3; MOM. FLUX = 33.56 M**4/S**2.

*** FULL METEOROLOGY ***

****
*** SCREEN AUTOMATED DISTANCES ***
****

*** TERRAIN HEIGHT OF 4. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

DIST (M)	CONC (pCi/L)	STAB	U10M (M/S)	USTK (M/S)	MIX HT (M)	PLUME HT (M)	SIGMA Y (M)	SIGMA Z (M)	DWASH
10.	.0000	0	.0	.0	.0	.0	.0	.0	
100.	.1537E-02	4	20.0	20.0	5000.0	25.2	15.8	13.9	NO
200.	.1351E-02	4	20.0	20.0	5000.0	25.2	30.9	27.4	NO
300.	.9378E-03	4	10.0	10.0	3200.0	47.9	46.0	41.0	NO
400.	.7429E-03	4	8.0	8.0	2560.0	58.6	60.6	54.2	NO
500.	.6003E-03	4	8.0	8.0	2560.0	58.6	74.3	66.7	NO
600.	.5848E-03	5	3.0	3.0	5000.0	83.4	63.4	41.4	NO
700.	.6610E-03	5	2.0	2.0	5000.0	94.8	72.7	46.8	NO
800.	.7269E-03	5	2.0	2.0	5000.0	94.8	80.8	50.2	NO
900.	.7915E-03	5	1.0	1.0	5000.0	118.1	90.8	57.0	NO
1000.	.8564E-03	5	1.0	1.0	5000.0	118.1	98.4	60.0	NO
1100.	.9055E-03	5	1.0	1.0	5000.0	118.1	105.9	63.0	NO
1200.	.9408E-03	5	1.0	1.0	5000.0	118.1	113.2	65.8	NO
1300.	.9646E-03	5	1.0	1.0	5000.0	118.1	120.4	68.6	NO
1400.	.9789E-03	5	1.0	1.0	5000.0	118.1	127.5	71.3	NO
1500.	.9856E-03	5	1.0	1.0	5000.0	118.1	134.4	74.0	NO
1600.	.9864E-03	5	1.0	1.0	5000.0	118.1	141.2	76.6	NO
1700.	.9824E-03	5	1.0	1.0	5000.0	118.1	147.8	79.1	NO
1800.	.9748E-03	5	1.0	1.0	5000.0	118.1	154.4	81.5	NO
1900.	.9644E-03	5	1.0	1.0	5000.0	118.1	160.8	83.9	NO
2000.	.9519E-03	5	1.0	1.0	5000.0	118.1	167.1	86.3	NO
2100.	.9379E-03	5	1.0	1.0	5000.0	118.1	173.3	88.6	NO
2200.	.9228E-03	5	1.0	1.0	5000.0	118.1	179.4	90.8	NO
2300.	.9070E-03	5	1.0	1.0	5000.0	118.1	185.4	93.0	NO
2400.	.8907E-03	5	1.0	1.0	5000.0	118.1	191.3	95.2	NO
2500.	.8742E-03	5	1.0	1.0	5000.0	118.1	197.1	97.3	NO

```
MAXIMUM 1-HR CONCENTRATI[illegible]T OR BEYOND    10. M: [illegible]
   129.    .1782E-02    4 [illegible] 20.0    20.0  5000.0    [illegible].2    20.4    18.0    NO
```

DWASH=   MEANS NO CALC MADE (CONC = 0.0)
DWASH=NO MEANS NO BUILDING DOWNWASH USED
DWASH=HS MEANS HUBER-SNYDER DOWNWASH USED
DWASH=SS MEANS SCHULMAN-SCIRE DOWNWASH USED
DWASH=NA MEANS DOWNWASH NOT APPLICABLE, X<3*LB

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********************************************
*  SUMMARY OF TERRAIN HEIGHTS ENTERED FOR  *
*    SIMPLE ELEVATED TERRAIN PROCEDURE     *
********************************************
```

TERRAIN HT (M)	DISTANCE RANGE (M) MINIMUM	MAXIMUM
4.	10.	2500.

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***************************************
*** SUMMARY OF SCREEN MODEL RESULTS ***
***************************************
```

CALCULATION PROCEDURE	MAX CONC (pCi/L)	DIST TO MAX (M)	TERRAIN HT (M)
SIMPLE TERRAIN	.1782E-02	129.	4.

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***************************************************
** REMEMBER TO INCLUDE BACKGROUND CONCENTRATIONS **
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08-25-93
00:34:36

*** SCREEN-1.1 MODEL RUN ***
*** VERSION DATED 88300 ***

DGETON LANDFILL 8 INCH PORTABLE FLARE, COMPLEX TERRAIN

COMPLEX TERRAIN INPUTS:

SOURCE TYPE	=	FLARE
EMISSION RATE (mCi/S)	=	.1700E-03
FLARE STACK HEIGHT (M)	=	6.00
TOT HEAT RLS (CAL/S)	=	.5106E+07
RECEPTOR HEIGHT (M)	=	.00
IOPT (1=URB,2=RUR)	=	1
EFF RELEASE HEIGHT (M)	=	13.34

BUOY. FLUX = 84.66 M**4/S**3; MOM. FLUX = 51.62 M**4/S**2.

FINAL STABLE PLUME HEIGHT (M) = 109.5
DISTANCE TO FINAL RISE (M) = 200.2

			VALLEY 24-HR CALCS		**SIMPLE TERRAIN 24-HR CALCS**				
TERR HT (M)	DIST (M)	MAX 24-HR CONC (pCi/L)	CONC (pCi/L)	PLUME HT ABOVE STK BASE (M)	CONC (pCi/L)	PLUME HT ABOVE STK HGT (M)	SC	U10M (M/S)	USTK (M/S)
46.	150.	.1633E-02	.1633E-02	92.7	.1052E-02	24.1	4	20.0	21.5

08-25-93
00:34:36

*** SCREEN-1.1 MODEL RUN ***
*** VERSION DATED 88300 ***

IDGETON LANDFILL 8 INCH PORTABLE FLARE, COMPLEX TERRAIN

SIMPLE TERRAIN INPUTS:

SOURCE TYPE	=	FLARE
EMISSION RATE (mCi/S)	=	.1700E-03
FLARE STACK HEIGHT (M)	=	6.00
TOT HEAT RLS (CAL/S)	=	.5106E+07
RECEPTOR HEIGHT (M)	=	.00
IOPT (1=URB,2=RUR)	=	1
EFF RELEASE HEIGHT (M)	=	13.34
BUILDING HEIGHT (M)	=	.00
MIN HORIZ BLDG DIM (M)	=	.00
MAX HORIZ BLDG DIM (M)	=	.00

BUOY. FLUX = 84.66 M**4/S**3; MOM. FLUX = 51.62 M**4/S**2.

*** FULL METEOROLOGY ***

****
*** SCREEN AUTOMATED DISTANCES ***
****

*** TERRAIN HEIGHT OF 0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

DIST (M)	CONC (pCi/L)	STAB	U10M (M/S)	USTK (M/S)	MIX HT (M)	PLUME HT (M)	SIGMA Y (M)	SIGMA Z (M)	DWASH
10.	.0000	0	.0	.0	.0	.0	.0	.0	
100.	.3087E-03	4	20.0	21.5	5000.0	37.5	15.8	13.9	NO
200.	.1165E-02	4	20.0	21.5	5000.0	37.5	31.0	27.4	NO
300.	.9259E-03	4	15.0	16.1	4800.0	47.0	45.7	40.6	NO
400.	.7489E-03	4	10.0	10.7	3200.0	65.0	60.3	53.9	NO
500.	.6411E-03	4	8.0	8.6	2560.0	77.9	74.5	66.9	NO
600.	.5580E-03	4	8.0	8.6	2560.0	77.9	87.8	79.1	NO
700.	.4798E-03	4	5.0	5.4	1600.0	116.7	103.3	93.8	NO
800.	.5258E-03	5	3.0	3.3	5000.0	101.3	80.6	49.9	NO
900.	.5905E-03	5	2.0	2.2	5000.0	114.0	89.6	55.1	NO
1000.	.6438E-03	5	2.0	2.2	5000.0	114.0	97.3	58.2	NO
1100.	.7004E-03	5	1.0	1.1	5000.0	140.1	107.1	65.1	NO
1200.	.7578E-03	5	1.0	1.1	5000.0	140.1	114.4	67.9	NO
1300.	.8055E-03	5	1.0	1.1	5000.0	140.1	121.5	70.6	NO
1400.	.8443E-03	5	1.0	1.1	5000.0	140.1	128.5	73.2	NO
1500.	.8752E-03	5	1.0	1.1	5000.0	140.1	135.4	75.8	NO
1600.	.8991E-03	5	1.0	1.1	5000.0	140.1	142.1	78.3	NO
1700.	.9168E-03	5	1.0	1.1	5000.0	140.1	148.8	80.8	NO
1800.	.9294E-03	5	1.0	1.1	5000.0	140.1	155.3	83.2	NO
1900.	.9376E-03	5	1.0	1.1	5000.0	140.1	161.7	85.5	NO
2000.	.9421E-03	5	1.0	1.1	5000.0	140.1	167.9	87.8	NO
2100.	.9435E-03	5	1.0	1.1	5000.0	140.1	174.1	90.1	NO
2200.	.9423E-03	5	1.0	1.1	5000.0	140.1	180.2	92.3	NO
2300.	.9390E-03	5	1.0	1.1	5000.0	140.1	186.1	94.4	NO
2400.	.9339E-03	5	1.0	1.1	5000.0	140.1	192.0	96.6	NO
2500.	.9274E-03	5	1.0	1.1	5000.0	140.1	197.8	98.7	NO

```
MAXIMUM 1-HR CONCENTRATION AT OR BEYOND    10. M:
   194.   .1167E-02    4    20.0   21.5  5000.0    37.5     30.2     26.7     NO

 DWASH=   MEANS NO CALC MADE (CONC = 0.0)
 DWASH=NO MEANS NO BUILDING DOWNWASH USED
 DWASH=HS MEANS HUBER-SNYDER DOWNWASH USED
 DWASH=SS MEANS SCHULMAN-SCIRE DOWNWASH USED
 DWASH=NA MEANS DOWNWASH NOT APPLICABLE, X<3*LB

     ***************************************
     *** SUMMARY OF SCREEN MODEL RESULTS ***
     ***************************************
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CALCULATION PROCEDURE	MAX CONC (pCi/L)	DIST TO MAX (M)	TERRAIN HT (M)	
SIMPLE TERRAIN	.1167E-02	194.	0.	
COMPLEX TERRAIN	.1633E-02	150.	46.	(24-HR CONC)

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** REMEMBER TO INCLUDE BACKGROUND CONCENTRATIONS **
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